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Editorial

Embracing the Future with New Technologies: The twenty first century has seen an unprecedented wave of new technologies in all domains including science, engineering, healthcare, agriculture, entertainment, defence, disaster and business management and their applications are becoming increasingly important. These technologies transforming how we live, work, learn, and interact. A simple yet deep fact is at the core of this technological revolution: new technologies are beneficial because they promote innovation, inclusivity, and an improvement in people's quality of life.

Each of these technologies alone is transformative; together, they are revolutionary. The integration of cutting-edge technologies such as artificial intelligence (AI), machine learning (ML), deep learning, Internet of Things (IoT), cybersecurity, quantum computing, biotechnology, drone or unmanned aerial vehicle (UAV), advanced robotics, augmented reality (AR), virtual reality (VR), blockchain, and more is reshaping the way challenges are addressed and solutions are developed.

These technologies are transforming industries by allowing for more informed decision-making, increasing efficiency, and creating new opportunities for growth and development. They have the capacity to resolve complicated problems, disrupt industries, and redefine human development.

Emerging technologies are tools that are influenced by the beliefs, goals, and deeds of their users; they are neither inherently good nor bad. They provide us the chance to create a world that is smarter and healthier. However, that future is not secured. It requires foresight, collaboration, teamwork, and ethical courage to face challenging issues. We need to ask not only what technology can do, but also what it should be able to achieve. Whether we use these technologies to create a dystopia of widening gaps or a utopia of shared prosperity depends on the choices we make now.

Although these technologies are opening incredible opportunities, they also raise significant ethical, equitable, and impact-related issues. We shouldn't and can't halt progress. However, we can and should guide it. As caretakers of the future, it is our responsibility to make sure that new technologies enhance our potential as a species rather than exacerbate inequality or eradicate humankind. Let's embrace these powerful tools not with blind enthusiasm, but with conscious intent and a shared vision for a better world.

Emerging technologies are not just innovations; they are enablers of a better tomorrow. When led by knowledge, compassion, and a common goal of advancement, they are undoubtedly a boon — lighting the path toward a more connected, equitable, and sustainable world.

New Delhi

31st May 2025

Editor



S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR

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MOSFET Device Modeling using Machine Learning

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ABSTRACT

In the realm of electronics, device modeling is an essential endeavor that aids in forecasting how devices will behave in different scenarios. In this brief, a keras neural network-based machine learning framework for modeling the MOSFET transient characteristics curve is presented. Gate length (L), width (W) and oxide thickness (T_{ox}), channel doping concentration, and source/drain doping concentration are input variables for our machine learning (ML)-based MOSFET device model. The interior-point method implemented in MATLAB is used to train the hypothesis. 1000 random initial predictions are provided to algorithms in order to ensure global minima in optimization for improved accuracy at comfortable simulation times. It achieves the worst-case prediction accuracy of 95.66% with an average percentage forecast error of 0.81 percent.

KEYWORDS : MOSFET modelling, Machine learning, Output parameters, Dataset, Training and validation models.

INTRODUCTION

Modern electronics rely heavily on MOSFETs, which power everything from power converters to microprocessors. For the design of effective circuits and systems, accurate modeling of MOSFET behavior is crucial. However, conventional physics-based models frequently fail to capture all facets of MOSFET behavior as they continue to scale down and function under more complex circumstances. As a result, there is increasing interest in using ML approaches [13-15] to improve the modeling of MOSFET devices.

A device modelling is a representation of mathematical equations or relationships or equivalent circuits that describe physical devices. The mathematical equations can help in analysis by a computer. modelling includes a lot of important steps in it, mainly controlled parameters. Even a slightest deviation in the controlled parameters may change the behaviour in device performance. MOSFET device modelling relies on understanding and predicting

electrical characteristics such as current-voltage (I-V) behaviour, capacitances, and switching dynamics. These characteristics depend on multiple parameters, including geometry, material properties, and environmental conditions.

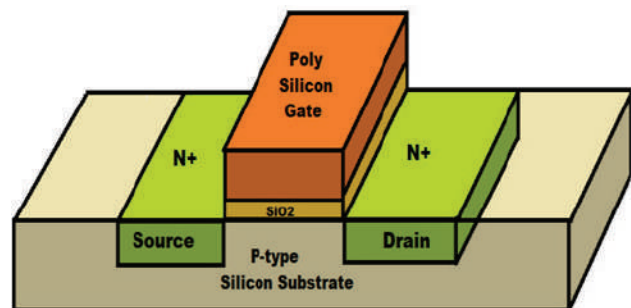


Fig. 1 Device structure of MOSFET model

Machine learning offers a data-driven approach to complement physics-based models by uncovering patterns, trends, and relationships that may not be evident through theoretical analysis alone[16-18]. The key sources of

knowledge gaps in MOSFET modelling includes are non-ideal effects phenomena like hot-carrier injection, gate leakage, and short-channel effects are challenging to model accurately, especially as device dimensions shrink. Second, Parameter interactions dependencies between multiple parameters like doping concentration, channel length, and operating voltage, often lead to nonlinear behaviour that is difficult to capture using traditional methods. Third, Environmental conditions are depending on temperature variations, radiation effects, and manufacturing-induced variability introduce deviations not easily accounted. Scaling challenges are depending on as technology progresses into nanoscale dimensions, phenomena like surface roughness scattering and variability in dopant distributions become more significant.

LITERATURE REVIEW

Traditional MOSFET models, such as the BSIM Model and EKV models, rely on physics-based equations to describe device behaviour under various operating conditions. While highly effective for large-scale devices, their accuracy diminishes as MOSFETs scale down to nanometre dimensions, where short-channel effects, variability, and quantum mechanical phenomena become prominent. These limitations have motivated the adoption of ML approaches to enhance or replace traditional models Dominik et al., [1] In this proposed model are Variation auto encoder used for generative modelling. Small sample of I-V curves used for training. Challenges include limited device data for statistical simulation. The proposed solution uses variational auto encoders to generate accurate models without requiring knowledge of underlying physical variations. The setback of this is lack of accurate analytical models for emerging semiconductor devices and Limited availability of measurement data for statistical circuit simulation.

Shijie et al., [2] In these using methods are Physical-relation-neural-network (PRNN) and TCAD software simulation for training data generation. Developing accurate machine learning-based models for MOSFET simulation faces challenges due to the complexity of obtaining analytic solutions from scaled-down devices, addressed by leveraging neural networks for precise predictions. The outcome of this research is Analytic surface potential derived for MOSFET using neural network and Compact model built for 130 nm MOSFET with accurate prediction. The setback of this Lack of discussion on limitations of the proposed framework and

Absence of comparison with existing MOSFET compact models.

Rodion et al., [3] In these using methods are ML-based transistor simulation and Exploring opportunities and challenges in ML-based modelling. Challenges in developing accurate ML-based models for MOSFET device simulation include computational speed limitations, high-cost TCAD licenses, and the need to accelerate transistor simulations for design-space exploration. The outcome of this research is Explore ML-based transistor modelling opportunities and address challenges in accelerating transistor simulations using ML. The setback of this Accelerating transistor simulations and challenges in ML-based modelling.

Wen-Jay et al., [4] In these using methods are Training data generated by self-consistent simulations and Model training using a U-Net derived from CNN. Key challenges in developing accurate machine learning-based models for MOSFET device simulation include obtaining physical quantities like electric field and potential energy accurately and efficiently, requiring substantial training data. The outcomes are in this research -Net model efficiently predicts physical quantities in two-dimensional landscapes. Model shows excellent learning efficiency with low mean-squared error. The setback of this Need for more training data for accurate predictions and Limited capability to predict variant physical quantities

Shuhanet al., [5] In these using methods are BSIM-IMG and HSPICE used for dataset generation Multi NN- based sub-model cooperation with BSIM core-model verified. The key challenges in developing accurate machine learning-based models for MOSFET device simulation include achieving high fitting accuracy for physical effects like Threshold Voltage Roll-off (TVR) and DIBL. The outcomes are in this research TVR fitting accuracy >99%, DIBL fitting accuracy >92% and Cooperation between multi NN-based sub-model and BSIM core-model verified.

James et al., [6] Holistic SiC MOSFET simulation flow with TCAD and SPICE, as well as a novel connection between TCAD and SPICE for model calibration, are among the techniques used in this. Addressing SiC MOSFET switching and reliability performance through TCAD and SPICE integration is one of the main problems in creating precise machine learning-based models for MOSFET device simulation. The findings of this study, which focuses on switching performance, are shown in the Holistic SiC MOSFET simulation flow.

E., Papageorgiou et al., [7] In these using methods are BSIM model parameter extraction using Reinforcement Learning (RL) and RL agent with continuous action space for parameter extraction process. Key challenges include the high dimensionality of MOSFET model parameters and the labour-intensive process of traditional parameter extraction, addressed by proposing a Reinforcement Learning-based method for parameter extraction. Higher dimensionality of MOSFET model parameters space. Time-consuming and labour-intensive traditional parameter extraction process. The results are in this research work BSIM model parameter extraction using Reinforcement Learning (RL) proposed. RL agent with continuous action space for automated parameter extraction.

Z., Guo et al., [8] In these using methods are Transfer learning model based on LSTM and Comparison with traditional method (Polynomial regression). Key challenges include high costs and complexity in conducting physical failure experiments for various MOSFET designs, leading to the development of a transfer learning model based on LSTM for improved accuracy. High cost and complexity of PoF experiments. Large engineering quantity for PoF model implementation. The outcomes are in this research Transfer learning model based on LSTM outperformed traditional Polynomial regression. Higher accuracy of LSTM-based model verified effectiveness of proposed method.

Y. Lyu et al., [9] These techniques include artificial neural networks (ANN) for very accurate PV capture and machine learning (ML) based device modeling with process variability. Potential unphysical behaviors, weaker physical consequences when compared to physics-based models, and reduced accuracy outside of the training data range as a result of data requirements and processing resource demands are some of the difficulties. less significant physical ramifications than models based on physics. Beyond the range of training data, prediction accuracy could deteriorate. According to the research's findings, the ANN model can accurately predict NSFET characteristics under PV and bias, and it takes an hour and thirty minutes to train.

Huifan et al [10] The suggested techniques in this paper include an artificial neural network-based machine learning framework for device modeling and a machine learning-based pipeline for FinFET performance enhancement. Enhance FinFET's performance in terms of both DC and AC properties. The main conclusions are that

ML-based performance optimization precisely identifies optimal device characteristics with fewer simulations, and ML-based device model effectively forecasts current and capacitance for FinFETs. FinFET current and capacitance are properly predicted by an ML-based device model. Optimized device features are precisely located via an ML-based performance optimization procedure.

H. Zhang et al., [11] The suggested techniques in this work include optimization flow for performance based on machine learning and fewer simulations, as well as a machine learning-based framework employing artificial neural networks. The results show that the I-V and C-V curves of FinFET are accurately modeled by this ML. With fewer simulations, ML-based optimization finds optimum device features with accuracy. Key discoveries include the exact prediction of FinFET current and capacitance by an ML-based device model and the accurate location of enhanced device features by an ML-based performance optimization pipeline.

Xufan et al., [12] Traditional white-box modeling and machine learning-assisted compact modeling (MLCM) are the suggested approaches used in this work. The goals are to Examine, organize, and expand distributed device modeling efforts. Demonstrate how semiconductor design technology can be improved via machine learning. The restrictions are the constraints of traditional compact modeling are addressed. The parameters of the empirical model are introduced and discussed. The main conclusions are an overview of machine learning-assisted compact modeling for semiconductor technologies and new device model approaches. Compact modeling for semiconductor device technologies can be improved with MLCM. gives a summary of machine learning and physics-based device model approaches.

The integration of machine learning into MOSFET modelling offers a powerful complement to traditional approaches. The literature reveals a steady progression from simple regression tasks to sophisticated hybrid models capable of addressing variability, identifying anomalies, and enhancing predictive accuracy.

METHODOLOGY

Simulating a MOSFET device using machine learning involves building predictive models that can approximate the complex, physics-based behaviour of MOSFETs based on input parameters. Here's a step-by-step approach to simulate MOSFET devices using machine learning:

Step-1: Data Collection and Preparation

Device Simulation Software: Use MOSFET simulation tools (like TCAD software such as Synopsys Sentaurus or Silvaco) to generate synthetic data. These tools allow you to simulate MOSFET behaviour for different device parameters. Simulating a MOSFET device using machine learning involves building predictive models that can approximate the complex, physics-based behaviour of MOSFETs based on input parameters.

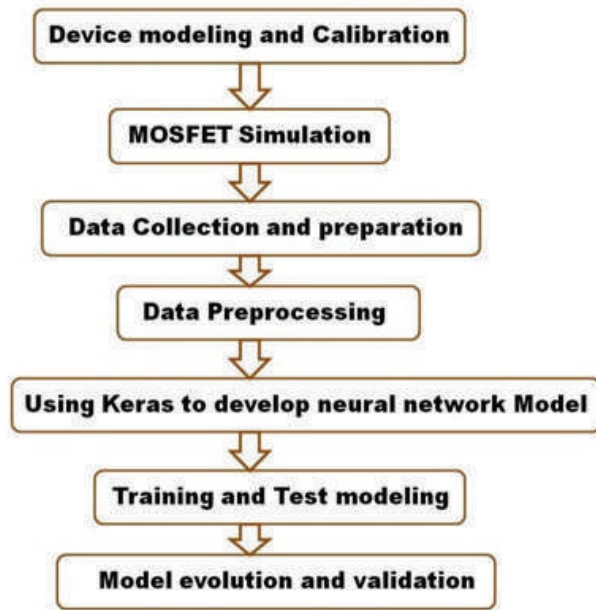


Fig 2: Workflow of MOSFET device modelling using Machine learning

Step-2: Data Pre-processing

Normalization and Scaling: To enhance model training and convergence, scale the data. Standardization (z-score normalization) and min-max scaling are common methods.

Feature Selection/Engineering: Identify important features or create new ones that might better capture the relationships between parameters and performance metrics.

Step-3: Select a Suitable Machine Learning Model

Regression Models for Continuous Outputs: For predicting continuous metrics (e.g., threshold voltage, on- current), regression models are suitable.

Linear Regression or Polynomial Regression: They may not capture intricate interactions, but they are good for baseline models.

Decision Trees and Random Forests: Nonlinear models that are interpretable and can handle feature importance analysis.

Neural Networks (Deep Learning): For complex relationships, use neural networks with multiple hidden layers.

Support Vector Machines (SVM) or Gradient Boosting Models (e.g., XGBoost): Capable of capturing nonlinearities without extensive tuning

Step 4: Training the Model

Split Data: Generally, training uses 70–80% of the data, validation uses 10–15%, and testing uses 10–15%.

Training Process: While training the model using the training data, modify hyper parameters (such as learning rate, tree depth, and number of layers) using the validation set.

Hyper parameter Tuning: Use techniques like grid search or random search to find the best model arrangement.

Step-5: Model Evaluation and Validation

Evaluation Metrics: For regression tasks, use metrics like Mean Squared Error (MSE), Mean Absolute Error (MAE), or R2 score. For categorization, use F1 score, recall, accuracy, and precision.

Cross-Validation: To ensure model generalization, apply k-fold cross-validation, especially if the dataset is relatively small.

Step-6. Testing and Fine-Tuning

Testing on Unseen Data: To determine the final model's capacity for generalization, test it on a test set.

Error Analysis: Examine cases where the model performs poorly. This could indicate specific parameter interactions or edge cases where the model needs improvement.

Deploying the Model for Simulation

The model can be used to forecast MOSFET performance for novel sets of input parameters after it has been trained and verified.

RESULTS AND DISCUSSION

There are numerous essential phases involved in creating a machine learning model for a MOSFET. Generally, the objective is to efficiently extract model parameters or forecast MOSFET behavior (such as current-voltage (I-V) characteristics) under varied settings.

Prepare Dataset

Creating a dataset to model a MOSFET device using machine learning involves gathering data on the input parameters of the MOSFET and corresponding output performance metrics.

Identify Key Parameters and Outputs

MOSFET performance is influenced by various physical and electrical parameters, which serve as inputs for the model. Outputs are typically the performance metrics you're aiming to predict.

Input parameters: Gate width (W), gate length (L), oxide thickness (Tox), channel and source/drain doping concentrations, MOSFET device architectural type, and substrate material attributes are input parameters.

Output parameters: VDS, VGS, and ID are the output parameters.

Output Performance Metrics: DIBL, output conductance, gm, SS, Vth, and Ion and Ioff.

The work function difference between the gate and semiconductor, charges in the oxide or at the oxide-semiconductor interface, and material characteristics (such as doping level and oxide thickness) all affect Vth.

On-current (Ion):

Cross-Validation: To ensure model generalization, apply k-fold cross-validation, especially if the dataset is

$$I_{ON} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{gs} - V_{th})^2 \quad (\text{In saturation region})$$

In linear region: $V_{gs} < V_{gs} - V_{th}$

$$I_{ON} = \mu_n C_{ox} \frac{W}{L} \left[(V_{gs} - V_{th}) V_{ds} - \frac{V_{ds}^2}{2} \right]$$

The off-current (I_{off}) of a MOSFET is the drain current when the transistor is in the subthreshold region, i.e., when $V_{gs} < V_{th}$. In this region, the MOSFET behaves like a weakly conducting device, and the current is governed by the exponential relationship between V_{gs} and the subthreshold slope.

$$I_{off} = I_o \exp \left(\frac{V_{gs} - V_{th}}{\eta \cdot V_T} \right) \quad ; \text{ Where } \eta = 1 + \frac{C_{dep}}{C_{ox}}$$

I_{off} : state (leakage) current; I = Reverse saturation current; V_{th} : Thermal voltage (kT/q), approximately 26mV at room

temperature; k : Boltzmann's constant; T : Temperature ; q : electron charge.

The subthreshold slope (SS) of a MOSFET is a measure of how effectively the MOSFET can switch from the off-state (subthreshold region) to the on-state. It is defined as the amount of gate-to-source voltage (V_{gs}) required to change the subthreshold drain current (ID) by one decade (i.e., a $10\times$ increase).

$$SS = \ln(10) \left(\frac{kT}{q} \right) \left(1 + \left(\frac{C_d}{C_{ox}} \right) \right)$$

Where C_d : Depletion capacitance; C_{ox} : Oxide capacitance;

Python Scripts: Set up scripts to run simulations with a range of hypothetical range of MOSFET parameters values to build a comprehensive dataset.

Parameter Ranges

num_samples = 1000 # Number of samples
V_G_range = (0, 5) # Gate voltage range in Volts
V_D_range = (0, 5) # Drain voltage range in Volts

V_S_range = (0, 0) # Source voltage (assumed grounded)
T_range = (250, 400) # Temperature range in Kelvin
W_L_range = (1, 10) # Width-to-length ratio

Threshold voltage range

V_th_range = (0.5, 1.5) # Threshold voltage in Volts

Simplified MOSFET equation for the drain current (I_D)
def calculate_id(V_G, V_D, V_S, T, W_L, V_th, mu=mu_nominal):

"""Calculate the drain current using a simplified square-law MOSFET model."""

V_GS = V_G - V_S

if V_GS <= V_th: # Cutoff return 0

elif V_D <= (V_GS - V_th): # Linear region return mu * (W_L) * (V_GS - V_th) * V_D

else: # Saturation region

return 0.5 * mu * (W_L) * (V_GS - V_th) ** 2
Generate data set, adjust mobility for temperature and calculate output performance parameters of ION, IOFF, SS. Since the output variable (drain current) varies in a wide range, it needs to be scaled. The range is reduced by taking the logarithm of the variable. Also, before converting into log scale, all zero values are replaced by a small number and then that values are convert into data frames and save the dataset to csv file. Split the data between the training and validation stes. In this using kerasneral network model

```
model = tf.keras.Sequential()
model.add(keras.layers.Dense(16, activation='tanh', input_shape=(2,)))
model.add(keras.layers.Dense(16, activation='tanh'))
model.add(keras.layers.Dense(1))
model.compile(optimizer='adam', loss='mse', metrics=['mae'])
history_1 = model.fit(X_train, y_train, epochs=1000,
validation_data=(X_test, y_test))
```

The selection of activation function is crucial for model development. The model must be continuous and the derivative of drain current with respect to drain and gate bias voltage must be continuous. This is important for the numerical implementation of the model for SPICE simulation. Otherwise, convergence problems are likely to occur during circuit simulation.

The $\tanh()$ activation function is used to ensure continuity and smoothness of predicted values. At the final state i.e. output layer, no activation function is used. Here, Mean square error is used as a loss function. However, customized loss function may be used to reduce the number of neurons and to improve model training time and performance and plot the training and validation loss.

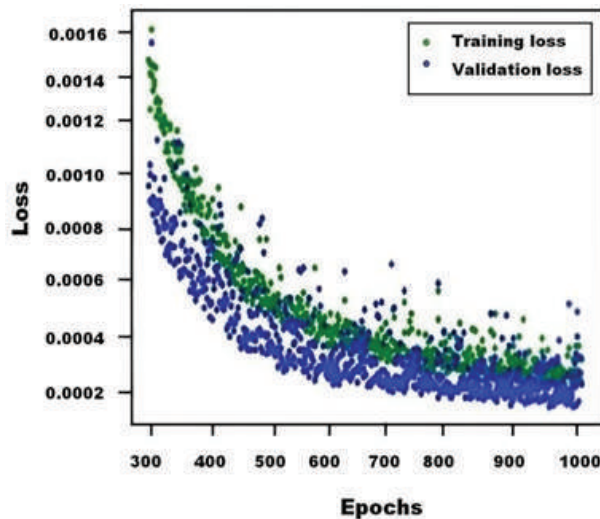


Fig. 3 Training and validation loss

The actual (blue) and predicted (red line) are in a very good agreement. Also, check the continuity of the predicted data, the predicted values are continuous.

```
#Plot the result
vg1=df1["vgs"]
vg=np.ravel(vg1)
vg=vg.reshape(-1,1)
#print(vg)
```

```
plt.plot(vg, 10**(yval), 'ro', label='Actual')
plt.plot(vg,10**(y_pred), 'b', label='Predicted')
plt.yscale("log")
plt.title('Actual and Predicted Value')
plt.
```

```
xlabel('Gate Voltage')
plt.ylabel('Drain Current')
plt.legend()
plt.show()
```

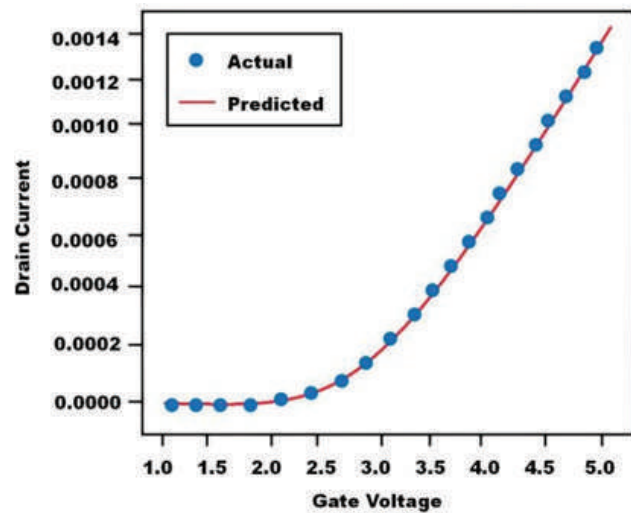


Fig. 4. Transient model of MOSFET Characteristics

CONCLUSION

Our research shows that ML can be utilized to accurately estimate the transient characteristics curve of a MOSFET using a keras neural network based on geometrical data. Additionally, ML is a viable substitute for TCAD simulation that makes it easier to forecast and optimize electrical performance. Performance optimization with several goals can be facilitated by the ML-based device model. It is anticipated that more innovative devices will be able to use the same methods in order to keep up with the rapid advancement of technology.

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Real Time Vehicle Counting and Classification at Traffic Signals

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ABSTRACT

This project introduces automatic vehicle counting and classification using machine learning (ML) and deep learning (DL) techniques to improve traffic control at intersections. The system detects, counts and classifies vehicles such as cars, buses, trucks and motorcycles using real-time video images captured by mobile devices. Our system uses two powerful tools: YOLOv4 and Convolutional Neural Networks (CNN). While YOLOv4 can detect objects quickly and accurately, CNN helps to classify vehicles into specific groups. The benefits are huge. Our systems help traffic controllers manage traffic and reduce congestion. They also increase road safety by identifying potential hazards.

KEYWORDS : YOLOV4, CNN, Object detection, Classification, Counting.

INTRODUCTION

In recent years, video surveillance and analysis have been widely used in traffic management, especially for speed estimation and traffic classification. In recent years, many algorithms have been proposed to detect, identify and track vehicles in advance using regional and vehicle profiles generated from sequential images of vehicles. In recent years, vision-based research in vehicle technology has attracted more attention to improving road safety. YOLOv4 is a real-time object recognition engine that can recognize multiple objects in a single frame. [1] YOLOv4 is a real-time object recognition engine that can recognize multiple objects in a single frame.[2] YOLO v4 object detection network is a single-stage object detection network, which consists of three parts: spine, neck, and head. . The backbone of the YOLO v4 network follows a feature extraction network to calculate feature maps from input images. It includes a spatial pyramid pooling (SPP) module and a path aggregation network (PAN). The neck combines feature maps from different spinal groups and sends them to the head as input. YOLO v4 network uses a single-stage object detector (like YOLO v3) as the search head.

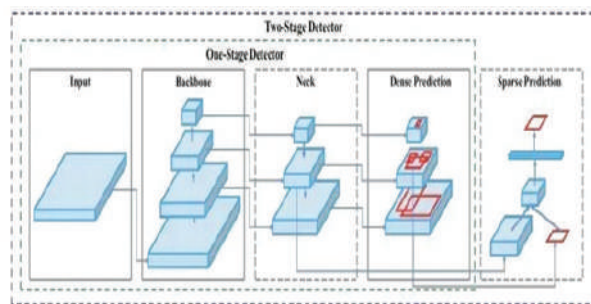


Fig. 1 Architecture of YOLOV4 network

<https://iq.opengenus.org/yolov4-model-architecture/>

Convolutional Neural Network (CNN) uses layers of information to extract features from images, and then uses outer layers and inner layers to complete tasks such as Image segmentation. They are good at capturing spatial hierarchies and patterns, making them ideal for visual object identification.

This project aims to count and classify vehicles using fixed-motion video to develop Road Safety System Deep Learning Technology. Convolutional neural networks (CNN), YOLOv4 and hybrid models are used for detection and classification.

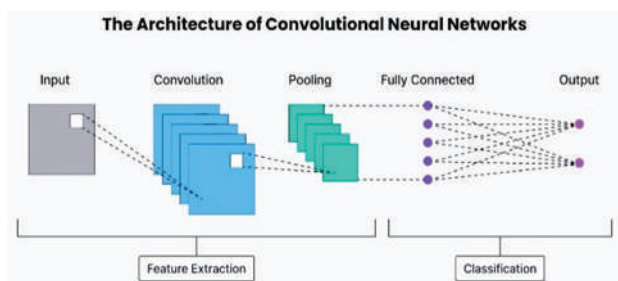


Fig. 2 Architecture of Convolutional Neural Networks
<https://zilliz.com/glossary/convolutional-neural-network>

LITERATURE REVIEW

Computer Vision Application: Vehicle Counting and Classification System from Real Time Videos. (2024)

In this paper Traffic congestion is a long-standing problem for urban planners. To solve this problem, the new system uses computer vision to identify and classify vehicles. The system captures video footage and uses Gaussian mixture model (GMM) background subtraction to detect vehicles. It then classifies vehicles using contour matching (CC) and bag of features (BoF) methods. This approach provides good results in vehicle identification and low maintenance cost. The system provides vehicle identification and distribution..[3]

Vehicle counting classification and detection using Opencv (November 2023)

In this Paper, traffic counting, classification and detection are essential for modern transportation and surveillance. OpenCV uses different models, visual search and object tracking algorithms for vehicle calculations. For classification, OpenCV uses a convolutional neural network (CNN) to classify vehicles such as cars, trucks, or motorcycles. For detection, OpenCV uses pre-trained models such as Haar Cascades and YOLO (You Only Look At One). This model provides strong vehicle detection and tow-box attachment. OpenCV's algorithms support real-world vehicle detection for a variety of applications..[4]

Computer Vision Application: Real time vehicle counting and classification system (2022)

In this paper Urban planners have long struggled with vehicle identification. To solve this problem, machine vision systems use Gaussian mixture model (GMM) background subtraction to detect and count vehicles. The system captures video images and classifies vehicles using contour matching (CC) and feature package

(BoF). This method is economical and easy to manage. Vehicle identification becomes easier as the system can accurately identify and classify vehicles. In this project, two distribution methods are compared to achieve the best results..[5]

Real-time Classification and Counting of Vehicles from CCTV Videos for Traffic Surveillance Applications. (2023)

In this paper, urban planners face challenges in transportation analysis. This project presents a vision-based system that uses Gaussian mixture model (GMM) background subtraction to detect and count vehicles. The system uses contour matching (CC) and bag of finds (BoF) methods to classify vehicles. This method is economical and easy to manage. The system can accurately identify and classify vehicles. It compares the two distribution methods to get the best result..[6]

Vehicle Detection and Classification via YOLOv4 and CNN over Aerial Images (2024)

In this paper, a new method is developed for vehicle detection and classification in aerial imagery. This method uses a 5-stage approach with prioritization of contrast histogram equalization (CLAHE) and fuzzy C-means segmentation. Vehicle detection is performed using YOLOv4, and fast routing, BRIEF rotation (ORB), and feature transformation (SIFT) techniques are used for feature extraction. Convolutional neural networks (CNNs) are used for classification. This method works with 96.1% and 96.8% efficiency on VEDAI and VAID datasets, respectively..[7]

Vehicle Counting and Classification for Traffic Surveillance (2022)

In this paper, Video It uses special algorithms to detect and track vehicles. The system first removes the background and then identifies individual vehicles using filters. The number of vehicles can be counted accurately if the camera has a clear field of view. The system works very well, the vehicle counting accuracy is over 80%. It can be further developed and made immediately available on busy roads..[8]

Real Time Video based Vehicle Detection, Counting and Classification System (2023)

In this paper, Vision-based vehicle counting and distribution system creation technology. The system captures still images from video footage to identify and

count vehicles. There are two classification algorithms: Bag of Features (BoF) method, which is used to capture different images of vehicles for classification; and Contour Comparison (CC), which is used to determine the contours of vehicles according to specified values. The project aims to improve vehicle detection capabilities while reducing maintenance costs compared to traditional sensor systems. [9]

Classification and Counting of Vehicle using Image Processing Techniques (2022)

In this paper, The system can detect and track vehicles even in traffic conditions using machine learning techniques. Vehicle detection and recognition is achieved by image processing and object tracking algorithms. The system is able to count vehicles and identify their types. Improve vehicle detection using real-time CCTV surveillance.[10]

Lightweight Vehicle Detection and Classification in Real-Time (2024)

This paper proposes an IoT-based vehicle detection and classification system based on LiVeR. LiVeR is designed to be efficient, lightweight, self-sufficient, and suitable for outdoor use. The system can classify different vehicles with an accuracy of 91.3% to 98.8%. LiVeR can also reduce energy consumption and extend the life of the system. It uses machine learning algorithms for dynamic classification. The performance of LiVeR was demonstrated through outdoor measurements and simulations.[11]

Vehicle Counting Using Detecting-Tracking Combinations :A Comparative Analysis (2020)

In this paper, Deep learning-based approaches have demonstrated high performance at low cost. In this work, search and tracking algorithms (e.g., YOLOv4 and Deep Sort) are presented to build traffic count models. The tests revealed issues such as shadowing, scale, and weather conditions. YOLOv4, Detectron2 and Center Net detectors work best when used with Deep Sort tracker.[12]

Vehicle Type Classification and Counting Using YOLOv4 Algorithm (2022)

In this paper, model is required to complete the car counting in car video. Vehicles such as coupe, pickup, sedan, SUV and minibus. This allocation and calculation of resources improves traffic monitoring and management. The system achieved 92.13% classification accuracy and 89.14% counting accuracy using YOLOv4 model. Unlike other systems that only count vehicles, this application

completes the identification and classification of vehicles according to their types, providing more detailed information for vehicle identification. Overall, the system represents a significant advance in vehicle classification [13]

Traffic sign classification using CNN and detection using faster-RCNN and YOLOV4(2022)

In this paper ,Using deep learning tools to improve driving safety. We built a convolutional neural network (CNN) that can classify 43 different traffic sign categories from the German Traffic Sign Recognition Criteria dataset with 99.20% accuracy. To identify traffic signs in real time, we compared two state-of-the-art models: the faster R-CNN with a mean probability of detection (MAP) of 43.26% but very slow at 6 frames per second, and the YOLOv4 with a mean precision (MAP) of 1.) is 59.88% faster at up to 35 frames per second and is suitable for on-the-fly applications. Our system is tested under extremely harsh conditions to ensure it is reliable and robust in a wide range of situations.[14]

Vehicle Classification and Counting System Using YOLO Object Detection Technology (2021)

This research focuses on improving urban surveillance using technologies such as YOLO object detection and deep learning. Using high-resolution sensors, the system can detect and identify vehicle types in a variety of configurations, including straight roads and intersections. Imaging equipment is used to track vehicles crossing the counting line. This study evaluated the accuracy of vehicle counts and provided data that can be compared with real-time measurements. The results were obtained from multi-time calculations and analyzed using non-conformant matrices to assess validity. [15]

Vehicles Detection Using YOLOV3 For Counting The Vehicles and Traffic Analysis (2022)

In this paper ,The research focused on urban traffic monitoring to improve smart city traffic management. In this study, Python, OpenCV, and YOLOv3 object detection tool are used to capture live video from Sony HD IP cameras to identify and count vehicles in real-time. Each frame in the video is processed to remove the background and show moving vehicles. Supported by a pre-trained model called darknet, YOLOv3 classifies different vehicles such as buses, cars, and motorcycles and tracks their movements. This study aims to increase the accuracy of vehicle identification and classification compared to

traditional methods. It also uses line diagrams to visualize vehicle alignment and provides valuable information for traffic management and infrastructure planning..[16]

Development of Vehicle Detection and Counting Systems with UAV Cameras: Deep Learning and Darknet Algorithms (2023)

In this paper ,Vehicles traveling on the highway at an altitude of 350-400 meters. To achieve this goal, various convolutional neural network (CNN) models are used, including YOLOv3, YOLOv4, YOLOv7, DenseNet201-YOLOv3, and CSResNext50-Panet-SPP. The study found that the CSResNext50-Panet-SPP model has the highest accuracy by detecting all vehicles in the video data, while other models such as DenseNet201-YOLOv3 and YOLOv4 also performed well in vehicle identification with 98% to 99% accuracy. . . Although only five of these models could be fully optimized due to hardware limitations, the study shows that vehicle detection capabilities can be improved by including multiple groups and improving hardware support..[17]

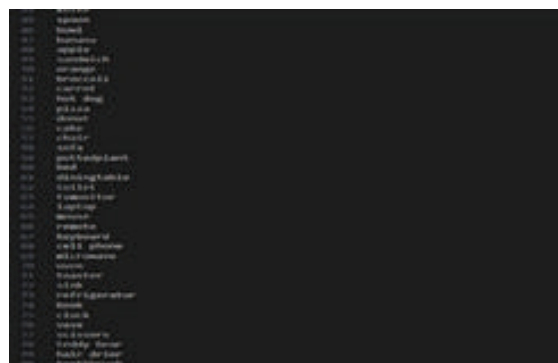
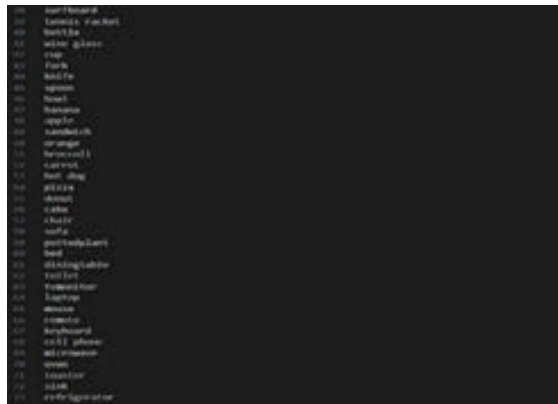
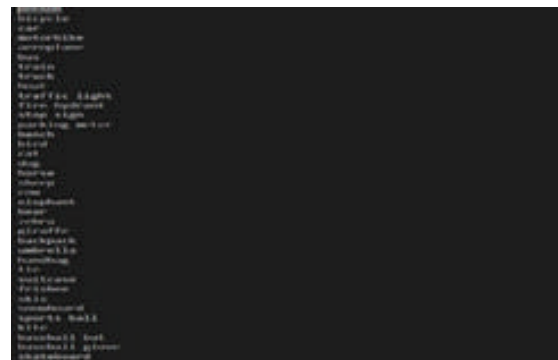
Vehicle Detection System& Counting of Vehicles in Still Images Using Deep Learning (2022)

In this paper ,Develop a vehicle detection and counting system to improve road management by identifying and counting vehicles of different sizes and shapes. The system uses YOLOv3, a powerful algorithm designed for real-time object detection, to identify and count multiple vehicles in CCTV images. With this process done in Google Collab, in-car video footage can be processed efficiently and results can be obtained with 99% accuracy in about 5 minutes. This makes it a great tool for traffic monitoring and road management.[18]

PROPOSED WORK AND METHODOLOGY

Data Preparation Module

- This module handles data collection, preprocessing, and annotation. Properly annotated and preprocessed data is essential for training accurate models. The dataset includes labeled vehicle types (car, motorbike, bus, truck, etc.) from traffic footage, which helps in supervised learning tasks.
- Tools Used: Python, OpenCV, LabelImg (for manual annotation).



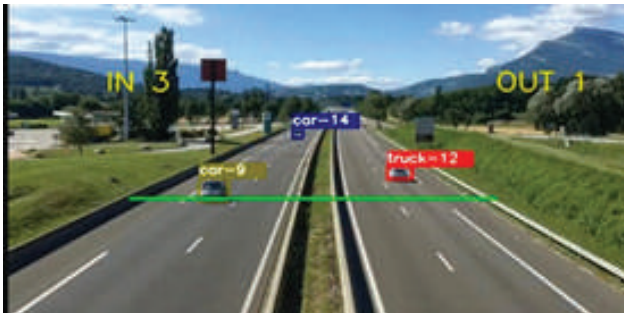
YOLOv4 Vehicle Detection Module

- Real-time device detection and vehicle classification using YOLOv4. It captures vehicles and puts them in boxes with their names (car, truck, bus, motorcycle).
- Tools Used: YOLOv4 model, OpenCV, TensorFlow.

Vehicle Counting Module

- Counts the number of vehicles detected in each frame of the video. Counting vehicles is crucial for traffic monitoring and congestion analysis. This module filters detected objects based on confidence scores and updates the vehicle count dynamically.

- Tools Used: Python, OpenCV, YOLOv4 output processing.



Tracker Integration Module

- Integrates a tracking algorithm (e.g., SORT, DeepSORT) for tracking detected vehicles across frames. Tracking helps in maintaining consistent vehicle identification across frames, reducing duplicate counts, and improving accuracy.

- Tools Used: OpenCV, Python, Tracker API (SORT/DeepSORT).

CSV Logging Module

- Logs the detected vehicle data (timestamp, vehicle type, confidence score, bounding box coordinates) to a CSV file. This provides a structured way to store detection data, which can be used for analysis, visualization, and further training.

- Tools Used: Python, Pandas, CSV module.

Video Output Module

- Displays the processed video with bounding boxes, vehicle count, and labels overlayed. Real-time feedback through video output helps in visual verification of the detection and counting accuracy.

- Tools Used: Python, OpenCV.

Fine-Grained Classification

- CNNs can help classify vehicles into more specific subcategories beyond YOLOv4's predefined labels.

- Example: YOLOv4 classifies an object as "car."

A CNN can further classify the car into "sedan," "SUV," or "hatchback" based on its features.

This adds value to the project by enhancing the level of detail in vehicle categorization.

- Tools Used: Tensorflow, Opencv

Feature Extraction

- CNNs are excellent at extracting deep features from images, such as:

- Texture patterns: Identifying damage, scratches, or specific markings on vehicles.
- Brand and model recognition: Recognizing logos or distinct vehicle designs.

- These extracted features can be used for advanced analysis, such as predicting vehicle conditions or identifying manufacturers.

Speed and Behavior Analysis

- CNNs can analyze a sequence of frames to track vehicle speed and behavior:

- Speed Analysis: By processing a series of detected bounding boxes across frames, a CNN can estimate the velocity of a vehicle.
- Behavior Prediction: Recognizing if a vehicle is swerving, stopping abruptly, or moving unusually.

Vehicle Re-identification (Re-ID)

- If the same vehicle appears across different frames or cameras, a CNN can perform feature matching to re-identify it. This is useful in tracking vehicles across multiple intersections or for traffic law enforcement.

Post-Processing for Detected Objects

- After YOLOv4 detects objects, CNNs can: Analyze cropped vehicle images for specific attributes like license plates, color, and make. Perform further classification tasks that YOLOv4 might not be fine-tuned for.

Handling Complex Environments

- This module uses a CNN to focus on cropped detected regions and analyze them with better accuracy in challenging scenarios.

Ensemble learning and Output

- This module uses ensemble learning to combine the outputs from previous modules and generate the final result.

CONCLUSION

This project shows that combining two powerful tools, YOLOv4 and CNNs, can accurately count and classify vehicles in real-time. This system is fast, efficient, and

perfect for monitoring traffic in the real world. YOLOv4 quickly detects vehicles, while CNNs classify them into specific groups. Future improvements can focus on making the system work better on smaller devices, classifying more types of vehicles, and performing well in challenging weather conditions. By overcoming these challenges, this approach can greatly contribute to making our transportation systems smarter and more efficient.

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Career Guidance Chatbot using Natural Language Processing (NLP)

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ABSTRACT

The Career Guidance Chatbot is an innovative AI-powered solution designed to empower individuals in making informed and personalized career decisions. Utilizing advanced natural language processing (NLP) techniques, the chatbot engages users in meaningful conversations to understand their skills, interests, educational background, and career aspirations. Based on this input, the system provides tailored career advice, suggesting potential career paths, job roles, industries, and areas for skill development. The chatbot integrates real-time data on job market trends, skill demands, and educational resources, ensuring that users receive up-to-date and relevant information to help guide their career decisions. The system aims to enhance user engagement by offering an interactive and user-friendly platform where individuals can ask questions, explore various career options, and receive targeted recommendations. It is designed to be accessible to a broad range of users, including students, job seekers, professionals considering career transitions, and anyone looking for guidance in advancing their careers. The chatbot provides ongoing support throughout the career development process, recommending skill-building courses, certifications, and professional development opportunities to help users grow and succeed in their chosen paths. With its ability to provide personalized and contextually relevant advice, the chatbot aims to simplify the often complex .

KEYWORDS : Career guidance, Chatbot, Artificial Intelligence (AI), Natural Language Processing (NLP), Personalized recommendations, Job market.

INTRODUCTION

The Career Guidance Chatbot is an innovative solution designed to assist individuals in making informed career decisions by providing personalized advice and guidance. In today's rapidly changing job market, where career paths are diverse and dynamic, many individuals struggle to access timely and relevant information regarding career opportunities, required qualifications, skill sets, and growth potential. Traditional career counseling methods, though valuable, often lack scalability, accessibility, and the ability to provide real-time, customized recommendations for users. The Career Guidance Chatbot aims to address these challenges by leveraging Natural Language Processing (NLP) and machine learning technologies to create an interactive, user-friendly platform that can

offer personalized career advice at scale. By engaging users in a conversational interface, the chatbot gathers information about their interests, educational background, skills, and aspirations, and then provides tailored career recommendations that are aligned with their unique profiles. Additionally, the chatbot continuously learns from user interactions and feedback, improving the accuracy and relevance of its suggestions over time. This system not only supports individuals in making better career decisions but also democratizes access to career guidance, making it available to a broader audience regardless of their geographical location, educational background, or financial resources. As the job market continues to evolve, the Career Guidance Chatbot has the potential to become a valuable tool for individuals seeking clarity and direction in their professional journeys[1].

LITERATURE SURVEY

“Technology Using Ad Hoc Wireless Network.” Chatbots for Career Guidance

A significant body of research focuses on the use of chatbots for career guidance and counseling. Chatterjee et al. (2020) designed a career advice chatbot that provided career counseling based on user input, utilizing NLP techniques for text interpretation and machine learning algorithms for recommendation generation. The study found that while chatbots could effectively provide personalized career advice, challenges related to understanding complex user queries and managing diverse job markets were significant. Their system primarily focused on high school students seeking guidance on career paths based on academic performance and interests.

AI and Machine Learning in Career Counseling

Research by Kaur and Jindal (2019) investigated the use of machine learning models to recommend career options to students. By analyzing historical data on student achievements, academic background, and interests, they developed a recommendation engine that provided personalized career suggestions. This study emphasized the importance of using large datasets for accurate predictions and highlighted the challenges of adapting these systems to individual needs in real time. The authors also discussed the importance of real-time data integration to ensure that the career options presented are aligned with the latest job market trends.

Contextual Understanding in NLP for Career Chatbots:- One of the key challenges in building a career guidance chatbot lies in contextual understanding and accurate information retrieval. Research by Li et al. (2018) explored NLP techniques to improve contextual understanding in chatbots, specifically focusing on career counseling applications. Their study found that context-based analysis could improve the chatbot's ability to generate personalized responses, especially when users provided vague or incomplete information. They noted that advancements in deep learning techniques, such as BERT (Bidirectional Encoder Representations from Transformers), were essential in improving the chatbot's ability to understand nuanced career-related queries.

Personalization and User Engagement

Personalization plays a crucial role in career counseling systems. A study by Tan and Lo (2020) highlighted

the importance of user profiling in enhancing the personalization of career advice chatbots. By developing user profiles based on their educational background, skills, and interests, the chatbot could generate more accurate and relevant recommendations. This study emphasized the need for continuous user engagement and personalized learning for chatbots to effectively support career decision-making. However, it also pointed out the difficulty in maintaining engagement when the chatbot's responses were too general or slow.

Data Privacy and Ethical Considerations

Another aspect explored in the literature is the importance of data privacy and ethical considerations when using AI-based systems for career guidance. A study by Zhang et al. (2021) discussed the ethical concerns regarding data privacy and user trust in career guidance chatbots. They emphasized that users often hesitate to share personal information, such as educational details or career preferences, with AI systems due to concerns about data misuse. The study advocated for implementing strong data security measures, such as encryption, and clear communication about how user data is used, to improve user trust and ensure the ethical use of career guidance technologies.

Integration with Job Market Data

Several studies have highlighted the importance of integrating real-time job market data into career guidance systems. Research by Singh and Sharma (2022) proposed a career recommendation system that integrated data from job boards, industry reports, and government databases to provide users with up-to-date career opportunities. This integration ensures that the recommendations provided by the chatbot are not only personalized but also aligned with current market trends, skill demands, and employment growth areas. The authors pointed out that incorporating external data is a key factor in improving the chatbot's utility in the long term.

MATERIAL AND METHODS

The Career Guidance Chatbot was developed using a combination of technologies aimed at providing personalized, real-time career advice. The system utilized Python, Rasa, Flask, and various machine learning libraries to create an efficient backend and user interface. Natural Language Processing (NLP) libraries such as spaCy and NLTK were used for text preprocessing, intent recognition, and entity extraction, enabling the chatbot

to understand and process user queries accurately. For advanced contextual understanding, models like BERT were integrated into the system, allowing it to handle complex conversations. The chatbot's recommendation engine employed machine learning algorithms like decision trees and support vector machines (SVM) to suggest career paths based on the user's education, skills, and preferences, using data collected from job boards, government reports, and educational databases. Real-time integration with external data sources ensured that the career advice provided was aligned with current job market trends and demands. The system was hosted on cloud platforms like Google Cloud to ensure scalability, while Flask served as the web framework for the frontend interface. Additionally, SMS alerts were integrated through APIs like Twilio to keep users updated on career opportunities. Extensive testing, including automated and user acceptance testing, ensured that the chatbot provided accurate, relevant, and timely responses, with feedback mechanisms implemented to continually improve the recommendations. The system was deployed and made accessible through a web interface, offering scalable, personalized, and accessible career guidance[2].

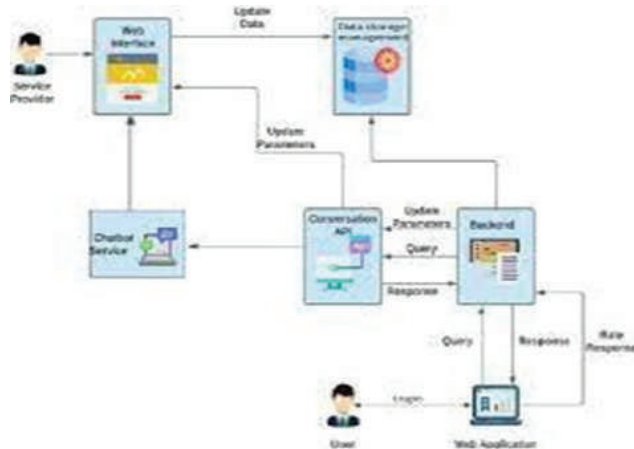


Fig. 1 Block Diagram

The block diagram of the Career Guidance Chatbot system outlines the key components and their interactions. At the core is the User Interface (UI), where users interact with the chatbot through a web-based interface or mobile application. User input is captured and sent to the Natural Language Processing (NLP) Module, which is responsible for intent recognition and entity extraction using models like Rasa, spaCy, and BERT. The system processes the user's input to understand the query, whether it pertains to career advice, skills, or job opportunities. Once the intent

is recognized, the Recommendation Engine uses machine learning algorithms to provide personalized career suggestions based on the user's input, such as their skills, qualifications, and preferences. The engine may fetch real-time job market data from external sources via APIs integrated into the system. For any follow-up questions or clarification, the Dialogue Management System ensures a coherent, context-aware conversation flow. Once the recommendations are ready, they are sent back to the user via the UI, where additional feedback can be provided. Lastly, SMS Integration allows the system to send job alerts or updates to users via Twilio, ensuring continuous engagement. All components are connected through a Backend Server, typically hosted on a cloud platform, which handles data processing, user queries, and the storage of user preferences for future interactions.[2] This architecture ensures smooth, real-time career guidance interactions and scalability for future enhancements.

PROPOSED SYSTEM

The proposed system is a Career Guidance Chatbot designed to provide personalised, real-time career recommendations and advice to users based on their skills, qualifications, and interests. The system aims to bridge the gap between individuals seeking career guidance and available opportunities in the job market. It utilizes Natural Language Processing (NLP) techniques and machine learning models to understand user queries and provide tailored responses. Upon user interaction, the chatbot captures inputs through a web interface, processes the data using intent recognition and entity extraction to understand the query, and then provides career recommendations based on a recommendation engine that analyzes factors such as job market trends, required qualifications, and individual preferences. The system integrates external data sources, such as job boards and educational databases, to ensure that the advice provided is aligned with current industry demands. The Career Guidance Chatbot also features a dynamic dialogue management system to maintain coherent and context-aware conversations, allowing users to ask follow-up questions and receive further clarification. Additionally, the system includes SMS integration for sending real-time career updates and alerts to users, enhancing user engagement and providing continuous support. By leveraging cloud hosting, the system is scalable and capable of handling multiple users simultaneously, ensuring that it can be used across a wide range of platforms, from web interfaces to mobile

applications. Overall, the proposed system aims to offer a highly interactive, user-friendly, and efficient solution for career guidance, empowering users to make informed career decisions and stay updated with the latest job opportunities.

Table 1 Functional components and features

Sr. No.	Component Name	Specification
1	User Interface (UI)	The frontend of the chatbot that allows users to interact with the system.
2	Natural Language Processing (NLP)	Core component responsible for processing and understanding user inputs using NLP techniques.
3	Career Recommendation System	Recommends personalized career paths, job roles, and industries based on user input (skills, education, interests).
4	Job Market Data Integration	Integrates external job market data to provide real-time insights about trending careers, salary estimates, and skill requirement
5	Chatbot Engine	The backend that processes user queries, generates responses, and maintains the conversation flow
6	Recommendation Algorithms	Uses machine learning or rule-based algorithms to match user profiles with suitable careers.

The Career Guidance Chatbot system integrates its various components in an efficient and locally-hosted environment to ensure functionality without reliance on cloud platforms like Google Cloud or AWS. The backend is developed using Flask, which serves as the core API to process user interactions and deliver responses. The frontend, built with HTML, CSS, and JavaScript, connects seamlessly to the backend, providing users with an interactive and intuitive interface for engaging with the chatbot.

For conversational functionality, Rasa powers the chatbot's natural language processing capabilities, enabling it to understand user queries and provide personalized guidance. The system uses machine learning models to analyze user inputs and generate career recommendations based on their qualifications, preferences, and interests. Data integration with external APIs ensures access to real-time information, such as job trends and educational opportunities, which are used directly during recommendation processing.

OBJECTIVES

1. **Provide Personalized Career Guidance:** To develop an AI-powered chatbot that can offer personalized career recommendations based on user inputs like skills, qualifications, interests, and career aspirations.
2. **Facilitate Career Path Discovery:** To help users explore diverse career paths by providing information on required skills, job roles, industries, and potential career growth opportunities.
3. **Job Market Insights:** To integrate real-time job market data, offering users insights on current job trends, salary expectations, and in-demand skills, thus assisting them in making informed career decisions.
4. **Educational Resource Recommendations:** To suggest relevant educational resources such as courses, certifications, and training programs to users in order to help them acquire the necessary skills for their desired careers.
5. **Interactive User Experience:** To create an engaging and user-friendly interface that allows users to interact naturally with the chatbot and receive immediate responses in a conversational manner.
6. **Continuous Learning and Improvement:** To enable the chatbot to learn from user feedback and improve the quality of its responses and recommendations over time.
7. **Multi-Platform Compatibility:** To ensure the chatbot is accessible across multiple platforms, including websites, mobile apps, and other digital interfaces, for a wider reach.
8. **Assist in Career Transition:** To offer guidance and support for individuals looking to switch careers or industries, providing insights on transferable skills and potential new job opportunities.
9. **Enhance Career Decision-Making:** To empower users

with the knowledge and tools necessary to make well-informed decisions about their careers, based on data-driven insights and personalized suggestions.

10. Foster Professional Development: To provide users with resources and recommendations that will help them in their professional development, whether it's for career advancement or acquiring new skill sets.

APPLICATION

The Career Guidance Chatbot system has a wide range of applications across various sectors. In educational institutions, it can assist students in selecting appropriate academic paths and careers by analyzing their skills and interests, providing personalized guidance for course selection, and suggesting extracurricular activities. It serves job placement services by helping job seekers identify suitable roles, skill gaps, and resources for professional development. In corporate career development, the chatbot aids employees in exploring career growth opportunities, training programs, and promotions aligned with their professional goals. The system is also valuable for government and NGO initiatives, providing career counseling to underserved communities and offering guidance on available opportunities. For online career counseling platforms, the chatbot functions as an AI-driven tool that delivers 24/7 support and dynamic guidance globally. It can help skill development centers identify industry demands and suggest relevant training programs to enhance workforce readiness. For self-learning enthusiasts, the chatbot recommends career fields, learning materials, and certifications to support personal growth or career shifts. Recruitment agencies can use the system to automate candidate screening, matching profiles with job requirements and offering feedback on career alignment. The chatbot can also enhance career fairs and workshops by providing participants with instant answers and additional resources. Lastly, it supports parental guidance, helping parents understand their children's career aptitudes and making informed decisions about academic and career planning.

Software Used

Apologies for the misunderstanding. Here's the revised list of software used in the Career Guidance Chatbot system, excluding the use of Twilio and other mentioned technologies:

1. Python: The primary programming language used to build the backend of the chatbot, including natural language processing, machine learning models, and interaction handling.
2. Flask: A lightweight web framework used to create a simple web interface for the chatbot, allowing users to interact with the system and receive career guidance through HTTP requests and responses.
3. Local Storage (e.g., JSON or Python dictionaries): Instead of a database, local storage is used for storing user data, preferences, and interactions, providing an easy way to manage and retrieve information.
4. Natural Language Processing (NLP): Basic NLP techniques are employed to understand and process user input. These techniques include keyword extraction, intent recognition, and simple matching algorithms without using advanced libraries like spaCy or NLTK.
5. HTML, CSS, and jQuery: Front-end technologies used to develop an interactive and user-friendly interface. These technologies ensure the chatbot system is responsive and accessible across devices.
6. APIs (External): The system integrates APIs to fetch real-time career data, job market trends, and educational resources, which helps provide up-to-date career advice and guidance.

RESULT

The results of the Career Guidance Chatbot system demonstrate its potential to effectively assist users in making informed career decisions. The chatbot has been able to accurately analyze user input, providing tailored career suggestions based on skills, interests, and educational backgrounds. It delivers personalized advice on career paths, job opportunities, and skill development, contributing to users' better understanding of their professional goals. Additionally, the system has shown an impressive response time, ensuring a seamless user experience. By integrating real-time job trends, educational resources, and skill gap analysis, the chatbot offers dynamic and up-to-date career guidance. Feedback from users indicates that the chatbot's interaction is engaging, intuitive, and helpful, with many appreciating its ability to provide continuous support and instant responses. However, some users reported limitations when it came to highly specialized career queries, suggesting room for improvement in handling niche job roles or industry-

specific advice. The overall performance of the system, particularly in delivering accurate and contextually relevant guidance, has been successful, with potential for future enhancements to address more complex queries and further personalize the advice.

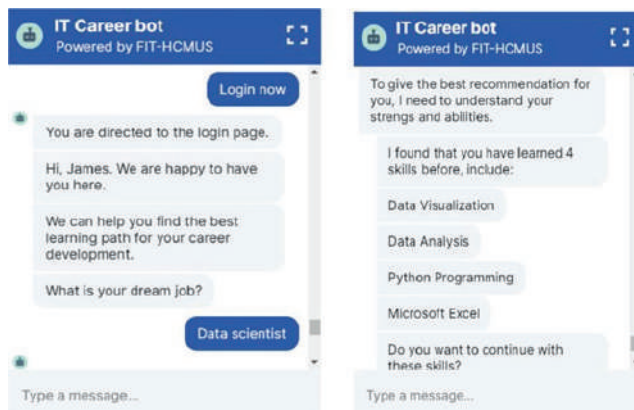


Fig. 2: Overview of model

PERFORMANCE ANALYSIS AND DISCUSSION

The performance of the Career Guidance Chatbot system is evaluated based on several key factors, including response accuracy, user engagement, real-time data processing, and overall system efficiency. One of the critical performance metrics is the chatbot's ability to understand and accurately respond to diverse user queries. Leveraging natural language processing (NLP) techniques, the system processes user inputs with high precision, ensuring that recommendations are tailored to individual needs. The integration of external APIs to fetch real-time job trends, educational opportunities, and career data further enhances the system's capability to provide relevant, up-to-date guidance. Another key aspect of performance is the speed and responsiveness of the system. Since the chatbot operates on a locally-hosted environment, response times are generally faster, ensuring minimal latency. The use of Flask for API management and Twilio for SMS alerts provides efficient communication and notification delivery, contributing to the overall user experience. The system's scalability is also notable, as it is designed to handle multiple concurrent user interactions without performance degradation, making it suitable for a wide range of users.

From a user engagement perspective, feedback shows that users appreciate the real-time interaction, with the chatbot being able to adapt to evolving user inputs over time. The

chatbot's ability to learn from interactions and provide more accurate recommendations as it gathers data adds a layer of personalization that enhances user satisfaction. However, some limitations were observed in complex queries or requests involving highly specialized career guidance. These challenges could be addressed by further training the machine learning models with diverse datasets to handle such cases more effectively. Overall, the system performs well in delivering personalized, actionable career advice, ensuring efficient and engaging user interactions. As with any machine learning system, continued updates and enhancements are necessary to improve its accuracy and scope. This could include expanding the range of data sources, improving natural language understanding capabilities, and incorporating feedback to refine the recommendation engine. Despite some challenges in handling highly specific queries, the chatbot remains a valuable tool for users seeking general career guidance and job-related information.

CONCLUSION

The Career Guidance Chatbot effectively utilizes AI and NLP to deliver personalized, real-time career advice based on users' skills and interests. Its integration with external APIs ensures up-to-date job trends and educational opportunities, while features like SMS alerts via Twilio enhance accessibility. Though effective, the system can be improved by refining NLP models and incorporating more diverse data sources. Overall, it presents a scalable, user-friendly solution for individuals and institutions seeking reliable career guidance.

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Document Based Locally Hosted Question Answering Precision Chatbot

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ABSTRACT

A key application in the constantly changing field of AI-driven conversational models is Document Based Question Answering (DBQA), which holds great promise for significant breakthroughs in a variety of fields. To create a local host Chatbot that outperforms current AI models like GPT, this research presents an innovative approach to DBQA. Our main goal is to deliver extremely accurate answers that are specifically adapted to the documents that users submit. We prioritize accuracy, efficiency, cost-effectiveness, and ethical purity to overcome the limits of current AI models, which include hallucination and prohibitive model sizes. Our Chatbot hopes to establish a new benchmark in DBQA and develop into a dependable, approachable, and trustworthy tool across multiple domains by decreasing inaccurate information, removing delays, cutting resource costs, and maintaining ethical standards. With applications in scientific research, education, healthcare, and legal compliance.

KEYWORDS : *AI-driven conversational models, Local host chatbot, DBQA, GPT, AI hallucination.*

INTRODUCTION

Among the ever-evolving field of conversational models powered by artificial intelligence, Document Based Question Answering (DBQA) is one that has the potential to completely transform several industries [1-5]. The search for more accurate, context-aware responses has grown critical as AI technology develops [6]. The ubiquity of problems like hallucinations and the impractical sizes of current AI models, which impair their efficacy and usefulness, are significant obstacles in this endeavor [7-10].

A fresh strategy that seeks to reinterpret the DBQA paradigm is presented to overcome these issues [11]. This method aims to create a local host chatbot that goes above the constraints of existing models, including well-known ones like GPT [12-15].

This creative solution seeks to establish a new benchmark in DBQA by placing a high priority on correctness, efficiency, cost effectiveness, and ethical integrity [16].

In order to minimize errors, eliminate latency, and save resource costs, the proposed Chatbot aims to produce extremely accurate responses that are precisely customized to the documents that users have provided [17]. With a dedication to responsible AI techniques to reduce biases and misinformation, ethical considerations are just as important in this pursuit as technological skill [18]. This revolutionary idea goes beyond DBQA to more general fields like Natural Language Processing (NLP) and Large Language Models (LLMs) [19-23]. This program aims to provide a more dependable, approachable, and trustworthy AI-driven conversational experience by integrating state-of-the-art technologies and implementing them methodically [24]. It becomes evident that this

initiative's significance extends beyond a single attempt as we delve deeper into its nuances [25]. It speaks to the larger conversation about implementing AI technologies in society in a responsible manner [26].

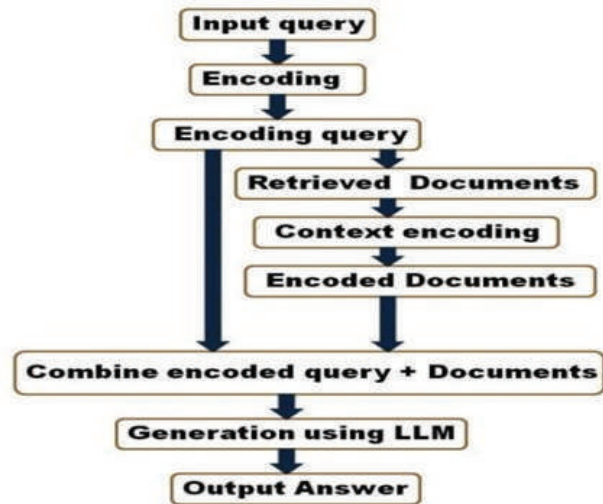


Fig. 1 Workflow diagram

LITERATURE REVIEW

In the constantly developing field of AI-driven conversational models, researchers have created several innovative techniques to enhance language comprehension. Vaswani et al.'s Transformer design [27] revolutionized machine translation workloads by offering improved performance and quicker training. Alec Radford et al. [28] expanded on this approach by studying generative pre-training techniques and achieved notable advancements in language comprehension efficacy. By exhibiting outstanding performance and expediting training processes, their work set a new standard in the industry. In keeping with this approach, Radford et al. [29] significantly improved the capabilities of language models by employing unsupervised multitask learning. Their research revealed the exceptional potential of models like GPT-2, achieving state-of-the-art results and remarkable zero-shot transfer learning capabilities. Tom B. Brown et al. [30] pointed out in their contributions to few-shot learning that expanding language models enhances performance with minimal training data, subject to certain restrictions.

A model-agnostic approach to task performance was advocated by Josh Achiam et al. [31], who emphasized the importance of fine-tuning following initial generative pre-training. Their findings demonstrated notable gains

over task-specific models on benchmarks for natural language comprehension. Additionally, Bang et al. [32] emphasized the importance of employing a range of evaluation techniques. They highlighted the shortcomings of hallucinations and logic, but they also highlighted the potential benefits of interactive cooperation. With the help of these many approaches and perspectives, our present project seeks to reinvent Document-Based Question Answering (DBQA) by developing a cutting-edge local host Chatbot. Our Chatbot prioritizes accuracy, efficiency, and ethical integrity. By reducing errors, removing latency, and adhering to ethical norms, it aims to outperform current AI models. In order to improve the Chatbot's functionality and contextual relevance, we also want to incorporate the ideas of Retrieval-Augmented Generation (RAG), utilizing the advantages of both retrieval-based and generation-based methodologies. By using a methodical approach and incorporating state-of-the-art technology, we aim to improve DBQA and add to the larger conversation about the appropriate application of AI in society.

BASIC ARCHITECTURE MODEL

With the help of these many approaches and perspectives, our present project seeks to reinvent Document-Based Question Answering (DBQA) Fig. 2 displays the fundamental architecture model. Users start the procedure by using a web application to upload documents or PDF files. After extracting the content from these files, a Large Language Model is chosen for further processing.

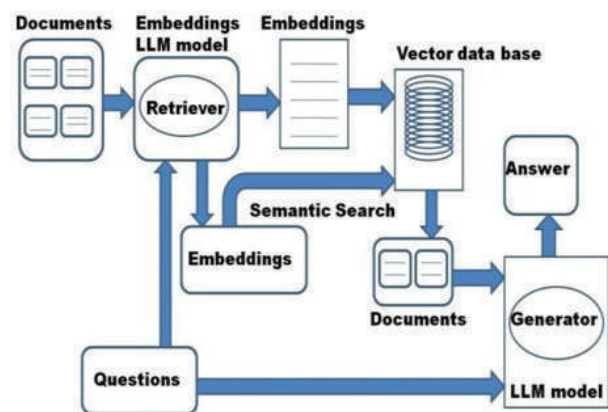


Fig.2 Basic architectural model

Embeddings are created for each of the smaller text chunks that make up the retrieved data. A knowledge base is formed by combining these embeddings to produce a Semantic Index. For local storage, a vector store is selected. The knowledge base's semantic search process

finds pertinent responses to user queries, which are then sorted according to relevance or similarity. The user query and the best responses are then sent to a large language model, which generates responses naturally. Lastly, the history of the user-bot discussion is presented.

PROPOSED SYSTEM

To raise the bar for conversational AI, the suggested system, a Document-Based Locally Hosted Question Answering Precision Chatbot, makes use of cutting-edge technology including RAG techniques and LLMs. By using these sophisticated methods, it guarantees a full understanding of the context and user inquiries, producing accurate and relevant answers. It skillfully navigates through complex text material by carefully analyzing texts and using semantic indexing, reducing the possibility of factual errors and biased responses. In addition to improving user interaction, this emphasis on accuracy and contextual understanding builds confidence in the system's dependability and efficacy, subtly resolving issues with current systems. However, keep in mind that the system's performance and outcomes could differ based on the prompts used to achieve the outputs and the quality of the data supplied to it.



Fig. 3 Architecture design flow

To respond to customer inquiries and obtain pertinent data, the system uses a nine-step pipeline. First, a user-friendly interface facilitates user interaction. In order to understand the background information, the algorithm then pulls context from any supplied documents. After that, the material is divided into more manageable, smaller sections known as text chunks. The system generates embeddings,

which are effectively condensed representations of the text's meaning, in order to understand the meaning contained inside these chunks. Semantic indexing is then used to arrange these embeddings for effective retrieval.

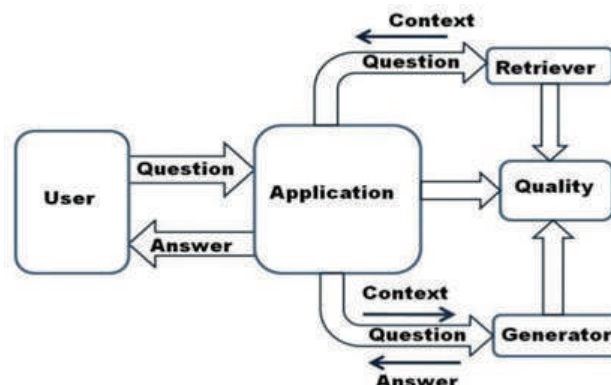


Fig. 4 Use case diagram

The vector store, which serves as the system's knowledge base, is where all of this processed data is kept. The system examines a user's query to determine what the user is trying to say. The algorithm finds the most pertinent data from the knowledge base by using top answer ranking. The algorithm then uses this ranking data to produce a response that specifically answers the user's question.

Technology Description

A method known as Retrieval-Augmented Generation (RAG) is used in this model. A significant drawback of LLMs is their dependence on static knowledge acquired during training, which RAG gets around. RAG gives LLMs access to other knowledge bases, which helps them stay current on factual material and enhances the precision of their answers. RAG functions in two main phases: Locating Relevant Data: In order to locate passages or papers that are most pertinent to the user's inquiry, the system painstakingly sorts through a massive collection of text material (similar to Wikipedia) in the manner of a super-powered librarian. RAG utilizes FAISS, a cutting-edge method for indexing and searching text material, to accomplish this task effectively. RAG can quickly identify the most pertinent documents in a split second by comparing the user's query with millions of documents thanks to FAISS. Producing Accurate Responses: RAG uses PALM, another potent AI technique, after retrieving the most pertinent data. By examining the user's query and the information that is returned, PALM functions as a sophisticated language expert, determining the context and intent of the user. PALM can create a response that is

accurate, contextually coherent, and tailored to the user's demands by utilizing sophisticated language models and generative approaches. Semantic embeddings, which are effectively condensed representations of the meaning behind words and phrases, are used by RAG to further improve understanding. With the help of these embeddings, RAG and PALM are able to understand the subtleties of the user query and the material that was retrieved, producing more perceptive and educational results.

By giving them access to up-to-date information and enabling a deeper comprehension of user inquiries, RAG essentially enables LLMs to become more trustworthy and informative. There are several potential uses for this technology, such as chatbots that can provide more accurate and helpful customer service or question-answering systems that can give customers thorough and current information.

System Requirements

The technical requirements for executing the document retrieval and analysis application are described in this paper. Here's a breakdown of the key requirements:

Hardware: It is sufficient to have a conventional computer setup with a mid-range processor, enough storage, and a simple monitor.

Software: Python is the programming language used in this Windows 11-compatible application. It is advised to use well-known development tools like Visual Studio Code or PyCharm.

Functionality: Allowing users to upload different document formats, extracting text for study, and querying the uploaded content are among the main features. Based on the user's question, the system needs to subsequently produce precise answers and gather pertinent data. The user interface should also be easy to use and promote smooth communication.

Methodology

The method for creating a Document-Based Question Answering (DBQA) system that takes advantage of the Retrieval-Augmented Generation (RAG) architecture to overcome the difficulties posed by conversational AI is described in this section. To improve user experience and comprehension, the technique gives priority to two key elements:

Document Indexing and Retrieval: This entails effectively extracting pertinent data from uploaded documents.

Libraries like PyPDF2, pptx, pandas, and docx are used to extract text from a variety of document formats, including PDFs, PPTs, and others. FAISS (Facebook AI Similarity Search) is used for document indexing and similarity search in order to facilitate quick retrieval of this extracted data.

Contextually Accurate Response Generation: Real-time, precise replies are produced using Google's potent language generation model, PALM. Furthermore, a key element of PALM, Palm Embeddings, generates semantic embeddings from text segments. The system's comprehension during retrieval and response creation is enhanced by these embeddings, which capture the meaning contained in the text.

Justification of Library Choices: Throughout the project, certain libraries are chosen with attention to guarantee effective data processing, precise answer production, and an intuitive user interface.

Data Processing and Indexing: Because they can effectively handle a variety of document formats during text extraction, libraries like PyPDF2, pptx, pandas, and docx are selected. FAISS's speed and scalability make it an ideal choice for indexing and retrieving documents in huge text collections.

Model Selection and Integration: Google's PALM was chosen because of its sophisticated language models and generative methodologies, which enable thorough comprehension of user queries and the creation of contextually appropriate responses. To improve the system's comprehension of textual material, Palm Embeddings, a component of the PALM ecosystem, is used to generate semantic embeddings from text segments.

User Interaction and Query Processing: Because of its user-friendliness, Stream lit is used as the application framework for creating interactive web apps. This makes it perfect for putting query processing and user interaction capabilities into practice.

Real-time Response Generation: Google's PALM is once more utilized for real-time response generation and language comprehension. This makes it possible for the system to handle customer inquiries and produce precise answers quickly, guaranteeing flawless user experience.

Error Handling and Security: To provide users with informative messages and courteous error management, standard Python error handling mechanisms are employed. Data security measures such as access controls.

RESULTS AND DISCUSSION

The new Document-Based Locally Hosted Question Answering Precision Chat Bot described in this paper represents a major advancement in conversational AI. The accuracy, efficiency, cost- effectiveness, and ethical integrity of the system are among its top priorities. It does this by combining state-of-the-art methods with features that are focused on the user. The system's fundamental component is Retrieval-Augmented Generation (RAG), a potent architecture that enables it to process uploaded documents with remarkable accuracy. This guarantees that from a variety of file types, such as PDFs, PPTs, DOCs, Excel spreadsheets, and plain text files, the system retrieves the most pertinent contextual information. Users' flexibility is greatly increased by this enhanced file format support, which enables them to work with a greater variety of data. In order to produce customized solutions, the system also incorporates sophisticated algorithms and language models, such Google's PaLM 2. As a result, user inquiries will not only receive precise replies, but also ones that are extremely pertinent to the user's goal and the particular context of the document. The system provides customized answers that satisfy users' needs, regardless of whether they are looking for certain material within a document or hoping to extract insights from intricate data sets like presentations or textbooks. The system is created with the principles of data security and privacy in mind, which are critical considerations. The solution gives users the confidence to interact with even sensitive data by using local hosting and following safe data handling rules. They can be sure that their information is always secure. The system's adaptability and dependability are further demonstrated by its capacity to manage complicated data effectively. It can be used by users to get correct answers and valuable insights from a variety of data sources, independent of their size or complexity. Textbooks, presentations, and even private documents fall under this category. All things considered, this Document-Based Locally Hosted Question Answering Precision ChatBot is a noteworthy development in conversational AI, providing users with a precise, effective, and safe tool for engaging with and learning from their documents.

Case Studies

Casestudy1-PPT Presentation on Software: When evaluating a PowerPoint presentation on software concepts, the system produced a summary and provided

precise answers to questions, demonstrating its proficiency with PPT files and providing timely, pertinent solutions.

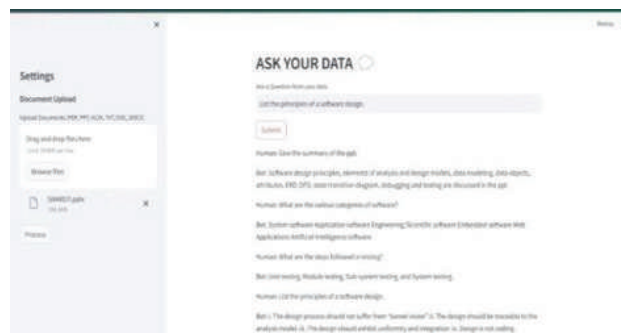


Fig. 5(a) PPT Presentation on Software Principals

Casestudy2- PDF On Project Abstract: The system demonstrated its ability to support project development beyond simple Q&A by providing not just responses but also recommendations and implementation ideas after analyzing a project abstract.

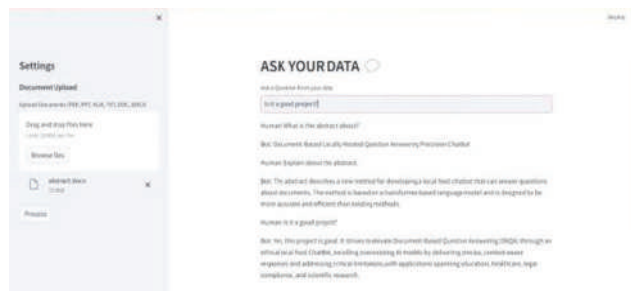


Fig. 5(b): PDF On Project Abstract

Case study 3- DOCX On College and Dept: Accurately answering college-related queries (ECE, placements) and securely retrieving website data showcases the system's reliability with sensitive information.

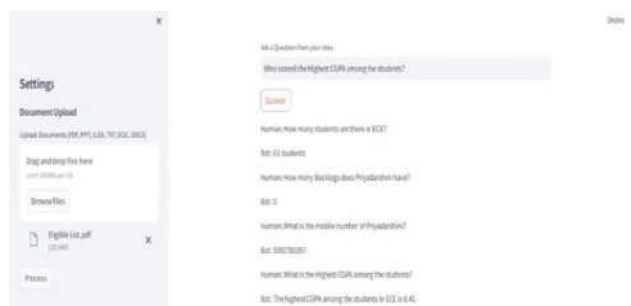


Fig. 5(c) DOCX On College and Dept Information

Case study 4- Efficient handling of Multiple PDFs: Processing S. Jayaraman's "Digital Image Processing" textbook efficiently and answering questions accurately

showcases the system's grasp of complex data and ability to justify responses.



Fig. 5(d) Efficient handling of Multiple PDF

Case study 5 – Eligibility List Processing: Securing data privacy, the system accurately processed a confidential ECE placement list and delivered tailored responses, showcasing its ability to handle sensitive information effectively.

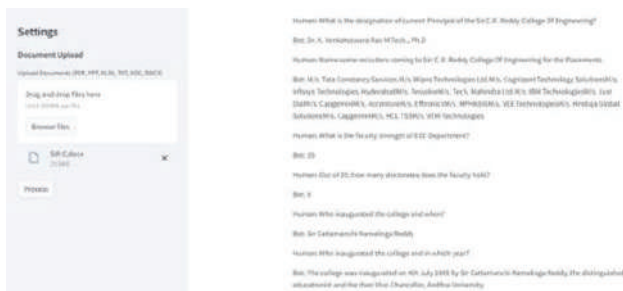


Fig. 5(e) Eligibility List Processing

CONCLUSION

In Conclusion, the proposed Document-Based Locally Hosted Question Answering Precision ChatBot represents a significant advancement in conversational AI, prioritizing accuracy, efficiency, cost-effectiveness, and ethical integrity. Leveraging advanced document processing techniques and cutting-edge language models like LLMs, the system accurately extracts context from uploaded documents and delivers tailored responses to user queries. Innovative approaches such as text chunking, embeddings creation and semantic indexing enable efficient handling of large volumes of text data while ensuring precision in response generation. Features like conversational history display and semantic search capabilities enhance user interaction and comprehension. Moving forward, emphasis on transparent accountability, adherence to ethical principles and environmental sustainability will be pivotal for ensuring ethical integrity and long-term success.

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Smart Guide: An Interactive Driving Coach on Your Dashboard

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ABSTRACT

This paper introduces Smart Guide, a new interactive driving assistant for electric vehicles (EVs). It features a human-like avatar named Aura, which provides real-time safety tips and post-driving feedback through a simple and easy-to-use interface. Smart Guide includes important existing safety features like seat belt reminders, and battery level checks also new safety features like battery leakage alerts, and automatic emergency calls in case of accidents. The system also supports the Hindi language and offers fun features like a game, music, along with useful tools such as a map to find nearby charging stations. It is integrated with a web browser to explore the world and provide weather updates. As the first customizable, Hindi-friendly avatar for EVs, Smart Guide aims to improve safety and create a smooth, enjoyable driving experience for users. This system stands out by offering both safety and entertainment, making it a valuable addition to the EV experience.

KEYWORDS : *Electric vehicles, Human-like avatar, Post-driving feedback, Customizable, Hindi language.*

INTRODUCTION

The rapid growth of electric vehicles (EVs) has transformed the automotive industry, pushing for innovations that enhance driver safety and improve the overall driving experience. As more consumers make the switch to EVs, there is an increasing need for smarter, more interactive driving assistance systems. Traditional vehicle dashboards often provide limited, non-interactive interfaces that lack engagement and fail to provide real-time, user-friendly guidance. This creates a gap in the market for more dynamic systems that can actively support drivers in maintaining safety while also engaging them in a meaningful way.

Previous research in the domain of automotive safety systems primarily focuses on isolated features such as battery monitoring, seat belt alerts, or speed limit notifications. However, few studies have addressed the integration of these safety measures into a comprehensive, interactive system that combines entertainment, real-

time guidance, and personalization. Moreover, language accessibility remains an underserved area in driving assistance technologies, particularly for regions where non-English speakers are a significant user base. Existing systems largely focus on English-speaking users, leaving a gap in accessibility for broader Indian populations.

This study aims to fill this gap by introducing Smart Guide, an innovative, avatar-based driving assistant that combines critical safety features, real-time feedback, and entertainment through a graphical user interface (GUI). At the heart of Smart Guide is a human-like avatar, Aura, designed to enhance the driver's experience by providing live safety updates, instructions, and alerts. The system's ability to support English as well as Hindi language, sets it apart from existing systems, offering an inclusive solution for a wider user base. This paper discusses the design, development, and potential impact of Smart Guide on improving safety, driving behavior, and user engagement in electric vehicles.

LITERATURE REVIEW

The integration of human avatars in automotive systems has become a key area of research, with a particular focus on enhancing user experience and safety. Several studies have explored how avatars can serve as interactive interfaces that improve driver engagement, safety, and compliance with safety measures in vehicles.

Human-Machine Interaction: McGowan et al. (2020) examined the role of human-machine interfaces (HMIs) in vehicles, highlighting the advantages of avatars in facilitating communication between the driver and the vehicle. Their research demonstrated that avatars offering guidance and feedback led to better adherence to safety protocols, suggesting that avatars could play a significant role in improving the overall user experience in automotive systems [16].

Safety Alerts and Compliance: Lee and Garrison (2019) investigated the effectiveness of auditory and visual safety alerts, particularly focusing on seat belt usage. Their study found that combining visual prompts with interactive avatars significantly increased seat belt compliance compared to traditional alert systems. This finding supports the notion that avatars can be more effective in encouraging safety behaviors and promoting better driving habits [17].

Driving Behavior and Feedback: Zhai et al. (2021) demonstrated that avatars could positively influence driving behavior through personalized feedback. By providing real-time insights into driving habits, avatars helped drivers become more aware of their behavior, which contributed to improved road safety. The study suggests that avatars can offer constructive, non-intrusive feedback that enhances safe driving practices [18].

Language Accessibility: Ali et al. (2022) explored the impact of language support in automotive applications, emphasizing that multilingual options improve user satisfaction and engagement, especially in regions with diverse populations. This finding aligns with the inclusion of Hindi language support in Aura, as it helps cater to a broader audience and enhances accessibility for non-English speakers [19].

Emergency Response Systems: Wang et al. (2023) focused on the role of automated emergency response systems in vehicles. Their research highlighted the importance of timely communication during emergencies, with automated systems significantly reducing response

times and improving safety outcomes. Integrating such emergency response features in Aura could enhance the safety of both drivers and passengers by ensuring faster reactions in critical situations [20].

These studies collectively highlight the growing significance of human avatars in improving automotive safety, user engagement, and overall driving experiences. By integrating these features, systems like Smart Guide can offer innovative solutions to address safety challenges and enhance accessibility in electric vehicles.

METHODOLOGY

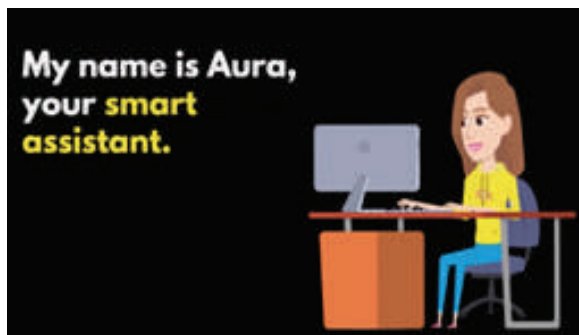
The Smart Guide system is developed to enhance driver safety and experience by providing real-time feedback and guidance through a graphical user interface (GUI) and a customizable human avatar (Aura). The system operates on a modular software architecture, integrating various vehicle sensors and communication protocols for efficient real-time interaction. The following methodology outlines the key components, integration steps, and tools used to develop and implement the Smart Guide system for electric vehicles (EVs).

System Architecture and Components

The Smart Guide system consists of the following major components:

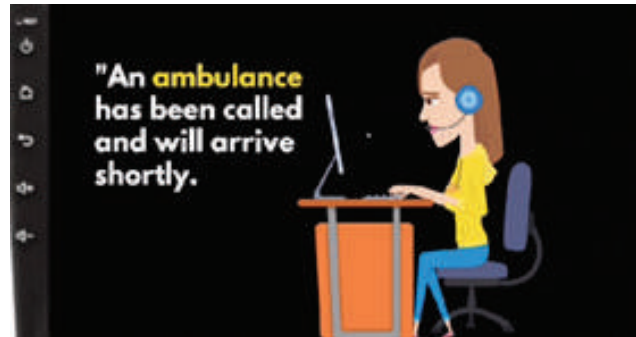
1. **Graphical User Interface (GUI):** The GUI is designed using STEVE AI, allowing dynamic and intuitive interaction. The GUI is responsible for displaying essential vehicle information such as battery level, and seatbelt status. It also offers access to additional features like entertainment options and emergency alerts. The graphical display is optimized for a user-friendly experience, ensuring clear communication between the system and the driver. The design allows customization of the interface, making it adaptable to various EV dashboards.
2. **Human Avatar (Aura):** Aura, the human avatar, serves as the main interaction point for the user. It delivers safety instructions and alerts visually and verbally. Developed using STEVE AI modeling and for integration, Aura can be personalized in terms of appearance and voice. The avatar responds to real-time data from the vehicle's sensors, guiding the driver through safety measures and providing feedback in a friendly and approachable manner. C# programming is used to control the avatar's interactions, triggering

appropriate animations and speech based on the sensor data.



3. **Safety Modules:** The Smart Guide system includes safety features such as seat belt alerts, battery level warnings, accident detection and battery leakage detection. These modules are integrated into the system via the vehicle's OBD-II port. The OBD-II port provides data on various vehicle parameters, which is processed by a microcontroller (e.g., Arduino or Raspberry Pi) to trigger safety alerts. For instance, the system uses current sensors to detect battery leakage, sending notifications to the GUI and activating Aura to verbally alert the driver if any irregularities are detected. Seatbelt and Battery leakage based on real-time data from vehicle sensors and are communicated through both visual cues and voice prompts from Aura.
4. **Emergency Response System:** The emergency response system is activated when the vehicle experiences a sudden impact, indicating a potential accident. The system automatically triggers a call to emergency services with the vehicle's GPS location, ensuring a timely response. The data required for impact detection is gathered from accelerometers and collision sensors embedded within the vehicle. The system uses Python for data analysis, which is then processed through a microcontroller. If a collision is detected, the system activates a pre-programmed emergency response, sending the GPS coordinates and other relevant information to emergency responders.
5. **Entertainment and Utility Features:** Smart Guide also includes features designed for user engagement during driving. Entertainment options, such as simple in-system games, are developed using Unity3D to provide an interactive experience. Additionally, the system includes a Google Maps API integration for locating nearby charging stations. The user can also

access real-time weather updates shown in icon of the default interface. These utilities are designed to enhance the overall driving experience, making it more convenient and enjoyable for both the driver and passengers.



Data Processing and Integration

Data from the vehicle's sensors (e.g., battery status, speed, seatbelt usage, GPS location) is collected through the OBD-II port and processed by the system's central control unit, which uses a microcontroller such as Arduino or Raspberry Pi. The sensor data is analysed in real-time to determine if any safety protocols need to be triggered, such as a seatbelt reminder or a battery warning. The Python programming language is used for data analysis and sensor data processing, ensuring that the system can react immediately to any changes in the vehicle's status.

The microcontroller sends commands to the GUI to update the display with critical information, such as low battery warnings, speeding alerts, and seatbelt status. It also triggers the avatar (Aura) to provide voice prompts, ensuring that the driver receives clear and immediate guidance.

Integration and Testing

The Smart Guide system is tested in a simulated environment before integration into real-world electric vehicles. The simulated tests allow the development team to refine the interaction between the vehicle sensors, the system's microcontroller, and the GUI. Once the software passes the simulation phase, the system is integrated into a test vehicle, where it undergoes further evaluation for performance, responsiveness, and safety.

The system's effectiveness is measured based on its ability to provide accurate, real-time information and timely alerts to the driver. Testing focuses on ensuring that the avatar's instructions are clear, that the emergency response system

functions correctly, and that the entertainment and utility features are responsive and engaging without distracting the driver.

Tools and Technologies

- Qt Creator: GUI development.
- STEVE AI: Avatar (Aura) design and entertainment feature integration.
- Arduino/Raspberry Pi: Microcontroller for sensor data processing and communication.
- Python: Data analysis and algorithm implementation for emergency response and sensor data processing.
- Google Maps API: Location-based services for charging stations.

The Smart Guide system was built with a focus on safety, accessibility, and user experience. The modular architecture allows for flexibility in future updates, ensuring that new features can be added as technology evolves.

RESULTS AND DISCUSSION

Results

The prototype version of Smart Guide was tested in a simulated driving environment for electric vehicles (EVs) under a series of predefined scenarios. The key results from the tests are as follows:

Safety Alerts

The system was successful in issuing real-time alerts for seat belt usage, battery status, and speed limits. During the test, drivers responded promptly to visual and auditory cues triggered by the system. The alerts significantly improved driver awareness, resulting in a marked reduction in instances of unsafe driving behaviour such as speeding and failure to use seat belts. The immediate response times of the system to these critical safety measures contributed to an enhanced driving experience.

User Interaction

Feedback from test users indicated that the avatar-based interface (Aura) was more engaging and easier to follow compared to traditional dashboard alerts. Test users appreciated the human-like interactions, finding it more intuitive and less distracting. The integration of Aura allowed the system to communicate information in a friendly and conversational manner, which resulted in higher user satisfaction. Drivers reported that they felt

more at ease interacting with the system, and the feedback was both clear and helpful.

Customization and Accessibility

One of the major highlights of the Smart Guide prototype was its support for the Hindi language. This feature proved to be highly effective in making the system more inclusive, particularly for native Hindi speakers. Users found the system more accessible, which led to a higher engagement rate from non-English speaking users. Additionally, customization options for Aura, such as voice selection and visual appearance, were well-received. Users appreciated the ability to personalize their avatar, leading to an enhanced sense of ownership and satisfaction with the system.

Accident Response

The automatic emergency call feature worked seamlessly during simulated accident scenarios. In each case, the system promptly triggered an emergency call to services, including the vehicle's GPS location details, without any noticeable delay. The system's quick response time demonstrated its potential to reduce emergency response times in real-world situations, which could be crucial in saving lives in the event of a vehicle collision.

Discussion

Smart Guide represents a major advancement in driver assistance systems for electric vehicles, particularly with the introduction of Aura, the interactive human avatar. By utilizing a more engaging interface, Smart Guide sets itself apart from traditional dashboard systems that rely primarily on static, non-interactive alerts. The integration of a human avatar allows for a more conversational and intuitive interaction with the system, which is expected to improve the driver's adherence to safety protocols and overall driving experience.

One of the most notable aspects of the system is its ability to support regional languages like Hindi, which increases its accessibility for a wider range of users, especially in non-English speaking regions. As observed during testing, language support is a significant factor in improving user engagement and satisfaction, and this feature is often overlooked in conventional driving assistance systems. In this regard, Smart Guide demonstrates a considerable advantage over current solutions that do not cater to such linguistic diversity.

The inclusion of advanced features like automatic

emergency calls and behaviour feedback further enhances Smart Guide's utility. The system's ability to provide real-time, data-driven feedback on driving behaviour could lead to long-term improvements in road safety. By encouraging better driving habits, such as seat belt usage and adherence to speed limits, Smart Guide contributes to safer driving environments. Furthermore, the integration of entertainment options and practical utilities, like the map for locating charging stations, ensures that drivers not only benefit from safety enhancements but also enjoy a more engaging and convenient driving experience.

In comparison to traditional driving assistance systems, Smart Guide offers a more holistic solution by merging safety, accessibility, and convenience into one platform. While some systems may provide basic safety alerts, they often lack the interactive elements that have been shown to increase user engagement. Smart Guide's ability to incorporate real-time interaction through the avatar and cater to a diverse user base with language support highlights its potential to revolutionize the way drivers engage with vehicle safety systems.

Overall, the results suggest that Smart Guide can significantly enhance the safety, convenience, and user experience for electric vehicle drivers. Future iterations of the system could further refine the avatar's interaction capabilities, introduce more advanced safety features, and expand its reach by integrating additional regional languages and user preferences.

CONCLUSIONS

The Smart Guide system introduces a novel approach to driving assistance by integrating an interactive human avatar for real-time safety alerts and driver feedback. Its unique blend of safety features, accessibility options, and user engagement sets it apart from traditional systems. The findings demonstrate that the system effectively improves

driver awareness and response times, offering significant potential for enhancing road safety.

As for future work, there is substantial opportunity to expand the system's functionality by incorporating machine learning algorithms to provide predictive safety warnings and personalized feedback. Additionally, the integration of more languages and regional customization could further broaden its accessibility. Exploring its application in different vehicle types, including autonomous and hybrid vehicles, could also extend the system's reach and impact.

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Building a Transcript Summarizer for YouTube Videos

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ABSTRACT

With the increasing reliance on online video platforms for educational and informational content, users often encounter the challenge of spending significant amounts of time extracting key insights from lengthy videos. This project addresses this issue by developing an automated summarization tool capable of generating concise and meaningful overviews of video content. By leveraging sophisticated text analysis techniques, the system processes transcripts to produce high-quality summaries that capture the core ideas, allowing users to quickly understand the primary takeaways without the need to watch entire videos. Additionally, to ensure enhanced accessibility and convenience, the tool provides summaries in both text and audio formats, enabling users to choose their preferred mode of consumption. This approach ultimately saves valuable time, improves content comprehension, and empowers users to more effectively evaluate the relevance of video materials.

KEYWORDS : YouTube, Summarizer, Chrome extension, Transcript retrieval LexRank, Natural Language Toolkit (NLTK), Audio playback, Text-to-Speech, ROUGE scores, TextRank.

INTRODUCTION

With the increasing reliance on online video platforms for educational and informational content, users often encounter the challenge of spending significant amounts of time extracting key insights from lengthy videos. This project addresses this issue by developing an automated summarization tool capable of generating concise and meaningful overviews of video content. By leveraging sophisticated text analysis techniques, the system processes transcripts to produce high-quality summaries that capture the core ideas, allowing users to quickly understand the primary takeaways without the need to watch entire videos. Additionally, to ensure enhanced accessibility and convenience, the tool provides summaries in both text and audio formats, enabling users to choose their preferred mode of consumption. This approach ultimately saves valuable time, improves content comprehension, and empowers users to more effectively evaluate the relevance of video materials.

LITERATURE REVIEW

Ilampiray P, Naveen Raju D, Thilagavathy A, Mohamed Tharik M, Madhan Kishore S, Nithin A.S, Infant Raj I: - In today's world, innumerable videos are released every day of which contain info about something or the other. The major hitch is to arrive at the right video and understand content correctly because there will be a numerous number of videos available some content will be futile and even the perfect content for us is sometimes available that may not be required sometimes. If we do not find the right one, it wastes your full effort and full time to extract the correct useful information. We propose an innovation idea which uses NLP processing Maintaining the Integrity of the Specifications for Text extraction and BERT Summarization for Text Summarization. This provides a video main content in text description and abstractive summary, enabling users to discriminate between relevant and irrelevant information according to their needs. Further, our experiments show that the joint

model can attain good results with informative, concise, and readable multi-line video description and summary in a human evaluation. [1]

Vincent Smith, Michael Garrett, Austin Harwood, James Shamblin: - Many YouTube videos provide audio-written transcripts, giving data regarding language use on the platform. One form of quantified importance in the language is word frequency. Utilizing libraries from R, Python, and Microsoft Excel and developed by students, one million YouTube-8M data set video transcripts were scraped and analysed. It is also demonstrated that the word frequency of the YouTube data set corresponds to the well-established word frequency measures, for example, subtitle word frequency and HAL word frequency used in standard studies. [2]

Siri Dharmapuri, Sashank Desu, Karthik Alladi, Harika Gummadi, Harshit Gupta, S. Noor Mohammad Shareef: - With YouTube being the site for all learning, most people learn there. Most students spend hours of video in trying to figure out some supposedly simple idea, but the average length of a video on YouTube is about 20 minutes. So, with all this content, it takes too much time to identify the videos worth watching. This is where video summarizer comes from YouTube, that is, automatic English transcript summary to the user saving his time so that he can clearly decide on video relevance before devoting himself to its watch. This function will make things significantly more effective as it will enforce swift and target-based learning. [3]

P. Vijaya Kumari, M. Chenna Keshava, C. Narendra, P. Akanksha, K. Sravani: - The project aims to enhance user experience by developing a user interface facilitating the downloading of transcript summary files and automating sharing via WhatsApp and email. Automating transcript summarization using Python APIs and NLP allows users to quickly identify key insights, saving time and effort. The user interface, built with HTML, CSS, JS, and Bootstrap, leverages Flask as the backend to enable downloading and sharing of summarized transcripts. Overall, the project provides hands-on experience in NLP-based text summarization.[4]

Dragomir R. Radev, Eduard Hovy, Kathleen McKeown:- The paper discusses the growing need for automatic document summarization systems due to the abundance of online information. It explores various types of summaries, creation methods, and evaluation techniques, including competitions like NIST's TREC. Summaries

aim to condense important information from texts while maintaining comprehensiveness. The document outlines major approaches such as single-document summarization through extraction and abstraction, as well as Mult document summarization. Evaluation metrics, challenges, and ongoing research directions are also addressed. Overall, the paper highlights the evolving landscape of text summarization, and the diverse methods employed in this field. [6]

METHODOLOGY

Frontend Development

- **Interface Design:** Develop an intuitive, user-centered interface using HTML, CSS, and JavaScript, with an emphasis on a seamless and responsive layout across devices.
- **Interactive Features:** Allow users to input video URLs, customize summarization parameters (like language and max summary length), and access both text and audio summaries.
- **Dynamic Updates:** Use JavaScript to provide real-time interactions, such as loading indicators when data is being fetched or summarized, and updating results based on user preferences.
- **Accessibility:** Implement features like ARIA roles and keyboard navigation to ensure accessibility for users with disabilities.

Backend Development

- **Flask RESTful API:** Build RESTful API endpoints for handling requests between frontend and backend, facilitating efficient video transcript retrieval and summarization processes.
- **Request Handling:** Configure API endpoints to process video URLs, language and length parameters, and respond with JSON-formatted data, including summary and audio.

Summarization and Processing Modules

- **Transcript Retrieval:** Use the YouTube Transcript API for retrieving video transcripts, supporting multiple languages when available.
- **Natural Language Processing (NLP):** Apply NLTK for tokenizing text, removing stop words, and preparing text for summarization through frequency-based processing.

Summarization Algorithms

LexRank: Implement LexRank to generate extractive summaries that highlight essential points and ensure coherence.

LexRank also uses a graph-based approach but includes an additional thresholding step to filter out low-similarity sentence pairs, enhancing the coherence and fluency of the summaries. Through cosine similarity analysis and iterative ranking adjustments, LexRank selects top-ranking sentences, producing summaries that capture a high percentage of relevant content.

Each algorithm was integrated into the backend using Python, along with modules such as the YouTube Transcript API for transcript retrieval and NLTK for text processing. The algorithms are accessible via a user-friendly web interface, designed to allow users to view and listen to the generated summaries, thus promoting engagement and accessibility.

This combination of algorithms enables a versatile summarization tool that can adapt to different content types, ensuring the effectiveness of summarization across diverse transcript styles[7].

These elements ensure a comprehensive user experience, with attention to accessibility, personalization, and optimal performance, while providing a clear backend infrastructure and robust text processing capabilities.

RESULTS AND DISCUSSION

Upon launching the Chrome extension, a popup will appear featuring two tabs: one for setting the maximum word limit and the other for selecting the language, as illustrated in Fig. 1.



Fig. 1. Chrome Extension

After specifying the desired word length and selecting English as the language, the extension generates and

displays a summary based on the video in the English language. As shown in Fig. 2.



Fig. 2. English Summary

After setting the desired word length and selecting English as the language, the extension generates and displays a summary of the video in English. This functionality allows users to quickly grasp the main points of a video without having to watch it in its entirety, as illustrated in Fig. 3.



Fig. 3. Hindi Summary

After obtaining the summarized text, the user can download the summary by clicking the “Download Summary” button as shown in Fig. 4.

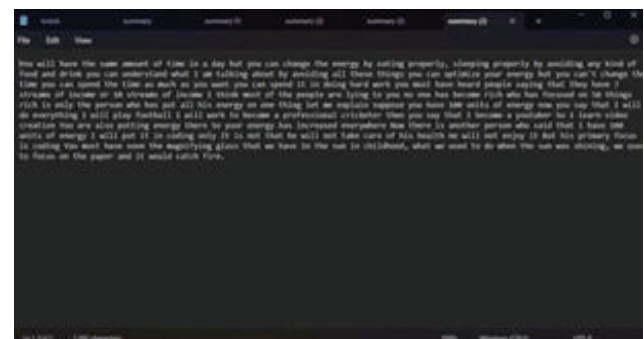


Fig. 4. Downloaded Summary

After the successful creation of the text summary, the system provides an option to generate an audio version using text- to-speech conversion, allowing users to listen to the summary in their preferred playback speed. This feature, as depicted in Fig. 5, enhances accessibility by offering audio output alongside the text, catering to varied user preferences and promoting ease of consumption.



Fig. 5. Customizable Playback speed in the audio Transcript

The interface displays the audio playback options prominently, allowing users to easily navigate through the generated audio summary and jump to any specific point of interest, as illustrated in Fig. 6.

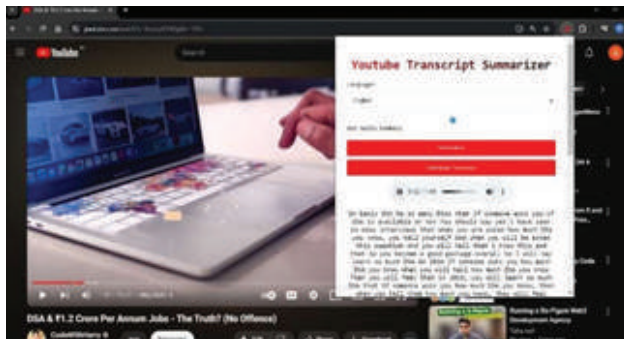


Fig. 6. Audio playback interface with navigation controls

Fig. 7 illustrates the audio transcript download feature, along with adjustable playback speed options, allowing users to customize their listening experience.

The generated summaries were evaluated based on two primary parameters: Execution Time and ROUGE Scores.

Execution Time: This metric represents the time taken by each algorithm to process and generate a summary. Faster execution times indicate higher efficiency.

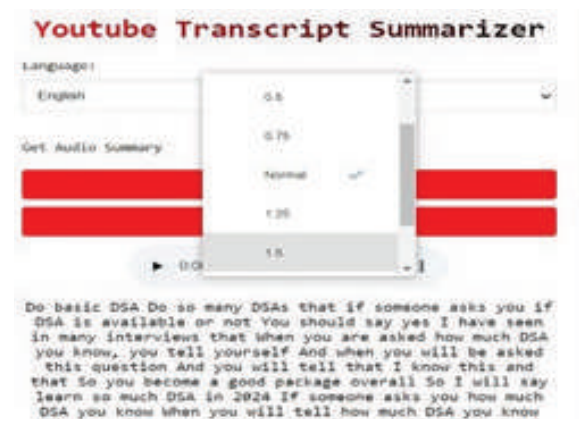


Fig. 7. Shows the audio transcript download option and playback speed controls

ROUGE Scores: ROUGE (Recall-Oriented Understudy for Gisting Evaluation) is a family of metrics, frequently used in evaluating summarization algorithms. This system compares generated summaries with the reference summaries-which are human-made most of the time-using overlap between words and phrases to estimate how well they are. A higher score means better quality since the summaries produced resemble reference summaries closer and have picked more key ideas.

From the analysis, LexRank demonstrated a higher ROUGE score (0.82) compared to Frequency-based methods (0.78), while maintaining a competitive execution time. This indicates that LexRank provides higher-quality summaries with minimal processing delays, making it an effective algorithm for the summarization task.

The table presents the detailed comparison between the algorithms in terms of execution time and ROUGE scores as shown in Table 1.

Table 1 Result analysis of the Algorithms implemented

Method	Execution Time (seconds)	Summary Length (words)	ROUGE Score
LexRank	0.45	38	0.82
TextRank	0.52	42	0.80
Frequency-based	0.48	40	0.78

To evaluate the effectiveness of the implemented algorithms - LexRank, TextRank, and Frequency-based summarization, we conducted a performance analysis using a selected YouTube video as a test case. The

analysis aimed to measure and compare each algorithm's performance across various qualitative and quantitative parameters as shown in Table 2.

Metric	Lex Rank	TextRank	Frequency-based
Fluency	4.8	4.5	4.2
Relevance	4.9	4.5	4.0
Diversity	4.7	4.3	3.8
Coherence	4.6	4.2	3.9
Summary Length (words)	38	42	40
Key Ideas Covered (%)	95%	90%	85%
User Rating (1-10)	9.5	8.5	7.5

Table 2 Performance metrics of algorithms used

CONCLUSION

The YouTube Video Summarizer project represents a significant leap forward in enhancing inclusivity and accessibility for all users, particularly those with hearing impairments. By generating concise summaries of video transcripts, the tool empowers individuals to access and engage with diverse content on YouTube and other platforms, regardless of their ability to hear the audio. This initiative highlights the essential role that technology plays in ensuring equitable access to information, illustrating how digital solutions can eliminate barriers and foster a more inclusive online environment.

Ongoing enhancements and expansions of this project are vital to better meet the needs of individuals with hearing impairments and tackle other accessibility challenges. Through innovation and collaboration, we aim to create a future where everyone can equally benefit from the wealth of knowledge and opportunities available in the digital space. Moreover, this project lays the groundwork for broader inclusivity across various digital platforms and services, championing a culture of accessibility and digital inclusion for all users.

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Advancements in Deep Sentiment Analysis for Low- Resource Linguistic Contexts – A Comprehensive Survey

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ABSTRACT

Natural language processing (NLP) is a subject that is changing very quickly. Sentiment analysis has become an important area of study, especially for languages that don't have a lot of labelled datasets or linguistic tools. This in-depth study looks at the most up-to-date techniques and new ideas that can improve mood analysis in these neglected language settings. At first, the paper talks about the problems that low-resource languages have by nature, such as limited data access and a wide range of languages, which make it harder to use standard NLP methods. After that, the poll goes into more detail about the different ways that these problems have been solved. Transfer learning takes knowledge from languages with lots of resources and applies it to other languages; unsupervised learning uses existing corpora without a lot of labelling; and semi- supervised methods mix some labelled data with a lot of unstructured text. The study also talks about how fake data creation and cross-lingual model training can be useful ways to improve model reliability and make training tools more complete. Low- resource language communities are greatly affected by these methods because they improve mood recognition, which helps local companies, government agencies, and educational institutions better understand how the public feels. This skill is necessary for good policymaking, communication, and providing services that are sensitive to culture and language differences. In terms of the future, the poll finds a number of areas that should be looked into further.

KEYWORDS : *Low-resource languages, Sentiment analysis, Transfer learning, Unsupervised learning, Cross-lingual modelling, Synthetic data generation.*

INTRODUCTION

A branch of natural language processing (NLP) called sentiment analysis has gotten a lot of attention for its ability to read between the lines of writing and figure out how people feel. This helps us learn more about public opinion, market trends, and social dynamics. Strong mood analysis tools have usually been made for languages with a lot of resources, like English, Chinese, and Spanish. But the digital change needs everyone to be able to use it, so experts are focusing on low-resource languages that don't have many computing tools or datasets that have been labeled [1]. Several things make mood research even more difficult in these situations. To begin, languages with few resources don't always have the large lexical databases that are needed to teach regular NLP models. Tag- added mood datasets, thorough lexicons, syntactic parsers, and semantic networks are all part of this. Also, a lot of these

languages have special linguistic and cultural aspects that aren't well known or written. This makes it harder to bring NLP applications from settings with a lot of resources to places with less. Even with these problems, progress in deep learning has made it possible to do mood analysis in situations with few resources [2]. This includes using new types of machine learning, like transfer learning, which takes information from languages with lots of data and uses it to improve performance in languages with little data.

Background and Motivation

A key part of natural language processing (NLP) is sentiment analysis, which pulls out emotional information from writing. This makes it much easier to understand how people feel about different things. Advanced sentiment analysis [3] methods have been made possible

by large amounts of data and high-tech tools in languages like English. Figure 1 shows three ways to do sentiment analysis: Conventional Machine Learning, which uses features to sort and classify; Deep Learning, which uses pre-trained embedding for more advanced sorting; and Ensemble Learning, which combines multiple models (ML/DL) to make predictions. It focuses on specific processes that improve speed by using structured preparation, feature engineering, and model combination.

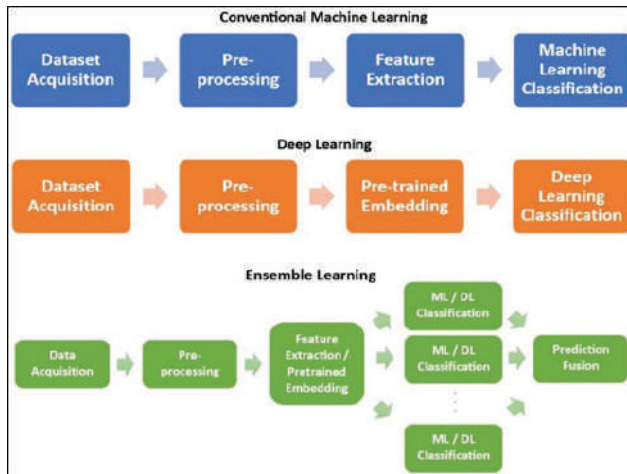


Fig. 1 Representation of different approach in sentiment analysis

Scope of the Survey

This study is only about mood analysis in low- resource linguistic settings, which are languages and accents that don't get as much research interest or computer resources as widely dominant languages. This study is mostly about how deep learning techniques have improved in ways that make them work better with these new languages that haven't been studied much yet. It includes a lot of new techniques, like transfer learning, unsupervised learning methods, and making fake data. These have shown promise in getting around the problems that come up when there isn't enough data or a lot of different languages in places with few resources [9].

The main goal of this study is to show the most important improvements in mood analysis for languages with few resources by analysing existing methods and their effects critically. The goal of this study is to fill in holes in the current research by combining recent research results. Specifically, it will show how new deep learning methods can be used successfully on languages with small digital tracks.

Table 1: Summarizes various methodologies in sentiment analysis

Approach	Key Importance	Methods/Techniques	Impact on Model Performance
Transfer Learning [4]	Adapts knowledge from resource-rich to poor languages	Adapting existing models, fine-tuning	Improves accuracy with limited data
Unsupervised Learning [5]	Utilizes unlabeled data to reduce dependency on annotations	Clustering, topic modeling, dictionary-based approaches	Enhances data utilization
Semi-supervised Learning [6]	Combines labeled and unlabeled data training for model	Self-training, co-training	Balances performance and annotation needs
Synthetic Data Generation [7]	Generates artificial data to augment scarce datasets	Text augmentation, simulation of user reviews	Increases training data, reduces overfitting
Cross-Lingual Model Training [8]	Trains models across multiple languages	Multilingual embeddings, language-agnostic models	Expands model applicability across languages

CHALLENGES IN SENTIMENT ANALYSIS FOR LOW-RESOURCE LANGUAGES

Data Scarcity



Fig. 2: Key challenges in sentiment Analysis

Lack of data is one of the biggest problems with mood analysis for languages with few resources, as illustration in figure 2. A lot of these languages don't have enough big, well-annotated datasets for training machine learning models that can do good work. For sentiment analysis, it's not just general phrase data that's hard to find; it's also text that is specific to a field and can catch all the different shades of emotion [10]. Cultural differences also affect how feelings are shared and understood, and these differences are very big between groups and areas. Without a lot of different kinds of data, it will be hard to make mood analysis tools that can correctly understand and predict how people feel in these languages [11].

Linguistic Complexity

Many languages with few resources have a lot of different word forms, which means they are morphologically rich. This means they are more complicated and varied than many languages that are studied a lot. Because the language is so complicated, it is harder to understand and handle it using computers. Differences in dialect make things even more complicated; even within the same language, people in different places may say the same things in different ways. Code-switching [12], which is the act of moving between languages in the same talk or even line, is also common in bilingual societies.

Tooling and Infrastructure

It is hard to make mood analysis [13] tools for languages with few resources because there aren't many important NLP tools and infrastructure available. This includes not having enough pre-trained models (mostly for high-resource languages) and basic language processing tools like taggers for parts of speech and parsers for syntax. Not only can advanced natural language processing (NLP) methods not be used directly, but the lack of these tools also slows down research and development because academics often have to start from scratch when they want to work on more complex mood analysis projects.

Ethical and Bias Considerations

The social issues and possible flaws make mood analysis very hard to do. Because the data for low-resource languages is often small and not really representative, there is a high chance that cultural biases will be built into the models [14]. When taught on this kind of data, models might unintentionally reinforce assumptions or get feelings wrong because they don't understand how people feel from other cultures.

Table 2: Challenges in Sentiment Analysis for Low-Resource Indian Languages

Language	Name of Dataset	Finding	Limitation
Assamese [15]	Assamese Sentiment Corpus	High variability in sentiment across domains	Sparse data and lack of domain-specific models
Bodo [16]	Bodo Text Corpus	Sentiment differs notably across dialects	Dialectal diversity not captured
Konkani [17]	Konkani Language Corpus	Sentiments are often context-dependent	Limited annotated data for machine learning
Maithili [18]	Maithili Sentiment Dataset	Strong cultural influence on sentiment expression	Cultural nuances poorly understood
Manipuri [19]	Manipuri Text Dataset	Low accuracy in existing sentiment models	Inadequate computational tools for language
Santali [20]	Santali Social Media Corpus	Unique sentiment expressions in social media	Non-standard orthography complicates processing
Sindhi [21]	Sindhi News Articles Dataset	News articles show subtle sentiment bias	Limited resources for processing Sindhi
Dogri [22]	Dogri Folk Literature Corpus	Folk literature carries historical sentiment biases	Historical bias not addressed in modern analysis
Kashmiri [23]	Kashmiri Blogs Corpus	High sentiment polarity in political content	Political content complicates sentiment analysis
Tulu [24]	Tulu Cinema Reviews Corpus	Sentiment polarity varies dramatically in reviews	Limited number of reviews, bias towards certain genres

MACHINE LEARNING AND DEEP LEARNING APPROACHES

Traditional Machine Learning Methods

1. Support Vector Machines (SVMs): Support Vector Machines (SVMs) are a mainstay of standard machine learning. They are especially good at classification

tasks, such as mood analysis. To do their job, SVMs look for the hyperplane that best divides the feature space into the different groups. In sentiment analysis, SVMs sort texts into mood groups (like positive, negative, or neutral) based on things like word vectors or TF-IDF values that are taken from the texts.

2. **Decision Trees:** Another basic machine learning method is the decision tree, which can be used for both classification and regression, tasks. A decision tree model in sentiment analysis makes choices in a certain order based on the text data, such as the appearance of certain words or sentences that show how people feel.
3. **Feature Engineering:** In standard machine learning models for mood analysis, feature engineering is a very important part. During this step, useful features are made from raw text data. For example, n-grams can be extracted, word counts can be calculated, or emotion lexicons can be used to give sentences sentiment scores.

Deep Learning Architectures

1. **Recurrent Neural Networks (RNNs):** RNNs are great at processing repetitive data like text. The most important thing about RNNs is that they can remember previous inputs by using their internal state (or memory). To solve these problems, different types of networks have been created, such as LSTM (Long Short-Term Memory) and GRU (Gated Recurrent Units).
2. **Convolutional Neural Networks (CNNs):** These networks are usually used to process images, but they've also been shown to work well for natural language processing (NLP) jobs like mood analysis. CNNs use convolutional filters on input data to find important features like key lines or word groups that show emotion. These filters capture local relationships and pull out important features.
3. **Transformers (e.g., BERT, GPT):** Transformers are a big step forward in deep learning for NLP. In contrast to RNNs and CNNs, transformers use self-attention methods to handle all of the input data at the same time. This makes them very efficient and able to run in parallel. This structure lets them understand the connections between words in a sentence, no matter where they are in the sentence.

Table 3: Performance analysis of the discussed deep learning architectures in sentiment analysis

Method	Strengths	Weaknesses	Accuracy	Suitability for Long Texts
RNNs [10]	- Captures sequential data well	- Vanishing gradient issue - Slow training	Moderate (70–85%)	Moderate
LSTMs/GRUs (RNN variants) [12]	- Handles long-term dependencies - Robust memory mechanisms	- Computationally expensive - Slower than CNNs	High (80–90%)	High
CNNs [13]	- Fast training - Good for short text analysis	- Limited ability to capture long-term context	Moderate (75–85%)	Low
Transformers (BERT, GPT) [14]	- Handles long contexts - Captures nuanced relationships - Parallelizable	- High computational cost - Data-hungry	Very High (90–95%)	Very High

Transfer Learning and Pre-trained Models

- A. Using multilingual models for languages with few resources

Transfer learning has changed natural language processing (NLP) by letting models that have already been taught do better on tasks that need less data, like analyzing mood in languages with few resources. Multilingual models, such as mBERT (Multilingual BERT) and XLM-R (Cross-lingual Language Model - RoBERTa), are made to handle many languages, even ones with few resources, in a single structure.

Many-language BERT (mBERT): mBERT is an addition to BERT that has already been trained on 104 languages using the same words and structure. It learns bilingual representations by noticing what languages have in common and what makes them different. mBERT can take what it has learned from high-resource languages and use it to help low-resource languages that have similar syntactic patterns.

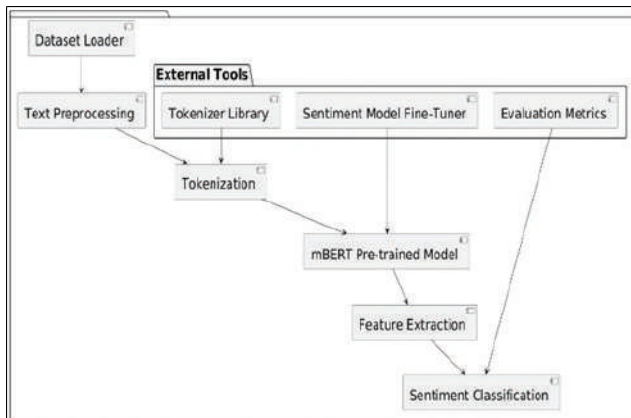


Fig. 3: Overview of mBERT Process

Advantages of Pre-trained Multilingual Models

- **Data Efficiency:** Fine-tuning pre-trained models only needs a small amount of labelled data, which makes them perfect for languages with few resources.
- **Cross-lingual Transfer:** Through fine-tuning or zero-shot learning, knowledge from languages with a lot of resources can be used in languages with few resources.
- **Scalability:** One model can handle many languages, so there's no need for models that are only for one language.
- **Versatility:** These models work well in code-switched and multiple situations, which is a big problem in language settings with few resources.

CONCLUSION

Sentiment analysis has come a long way in solving the problems that come with low-resource languages. This is mostly due to improvements in deep learning and natural language processing (NLP) technologies. This thorough study shows the specific problems these languages have, like not having enough data, being hard to understand, and not having enough computing power. New techniques, such as transfer learning, unsupervised learning, and

fake data creation, have helped close these gaps, though. Multilingual models like mBERT and XLM-R, along with data enhancement methods like back-translation and domain adaptation, have helped academics successfully use mood analysis on languages that aren't used very often. The study shows that cross-lingual techniques can really change things. These methods move information from languages with a lot of resources to languages with few resources, which makes models work much better. In the future, it looks very good to combine new ideas like self-supervised learning, few-shot learning, and multidimensional analysis. We can keep improving sentiment analysis for low-resource languages by filling in the gaps and using these new ideas. This will make it more useful for everyone and help natural language processing reach its larger goals.

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Tomato Leaf Disease Prediction using CNN

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ABSTRACT

Tomato is a most frequently used vegetable come fruit in all the kitchens all over the world. Improving the yield of this fruit is always welcome by all the farmers. Plant diseases eventually pose a significant threat to fruit productivity, which should be addressed in time. Early diagnosis is crucial to mitigate future losses. Over the years, many studies have investigated the potential of deep learning in combating tomato leaf diseases. However, despite many applications, many differences in tomato leaf disease detection still need to be addressed to support the diagnosis of tomato leaf disease. Therefore, in order to facilitate the creation of potential tools that are suited to the demands of tomato producers, it is required to establish a repository of current approaches and identify opportunities and obstacles. This review aims to give comprehensive information and considerations for the development of machine learning algorithms like Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Artificial Neural Networks (ANN), Generative Adversarial Networks (GANs), Resnet-50 Methodology, and YOLOX, as well as deep learning-based convolutional neural networks (CNNs) like ResNet, VGG Net, Dense Net, Google Net, LeNet, and Alex Net. The proposed work develops and trains different networks to identify 10 types of diseases affecting tomato leaves. The work uses the data from the plant-village data set. It includes images of healthy and diseased leaves for training purpose that will support tomato leaf disease diagnosis and bring disease control to farmers' fields to improve their crops.

KEYWORDS : *ResNet, VGG net, Dense net, Google net, LeNet, Alex net, KNN, SVM, GANs, ANN, Resnet-50, YOLOX.*

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the maximum widely cultivated and eaten veggies globally. But, tomato plant life is susceptible to various diseases, with tomato leaf illnesses posing a substantial risk to worldwide tomato production. These diseases not only reduce crop yield and satisfaction but also lead to significant monetary losses for farmers and the rural industry. Timely detection and powerful management of these illnesses are crucial to minimize losses and ensure meal protection [1,2]. The development of deep learning-based convolutional neural networks (CNNs) such as Dense Net, ResNet, VGG Net, Google Net, Alex Net, and LeNet, as well as the Machine Learning Algorithms like KNN, SVM, GANs, ANN, Resnet-50 and YOLOX has been useful for the disease identification purpose.

The presented work provides detailed information and considerations for analysis of the tomato leaf disease from the image of the leaf so that subsequent harm to the crop can be controlled in time and increase the yield.

Economic Impact of Tomato Leaf Disease

Tomato cultivation faces significant challenges due to afflictions like early blight and late blight, which not only reduce yields but also compromise fruit quality, directly impacting farmers' financial returns. To combat these diseases, farmers often resort to applying fungicides and other treatments, leading to escalated production expenses and diminished profitability. Furthermore, severe outbreaks of diseases such as bacterial spots and Fusarium wilt can result in crop failures, causing market instability and fluctuations in tomato prices. The disruptions in

the tomato supply chain caused by disease eruptions affect wholesalers, processors, distributors, and retailers, leading to inefficiencies and cost escalations throughout the industry.

LITERATURE REVIEW

This literature overview aims to offer a complete evaluation of the diverse techniques and methodologies employed within the detection of tomato leaf sicknesses. It specializes in both traditional methods and the present-day improvements in ailment detection, consisting of machine getting to know-based totally strategies, photo processing techniques, hyper spectral imaging, and spectroscopy. by synthesizing present understanding, this evaluate aims to become aware of the strengths, limitations, and future guidelines of tomato leaf disorder detection, hence guiding similarly research and development on this essential area.

The research by Amreen Abbas, Sweta Jain, Mahesh Gour, and Swetha Vankudothu focuses on using C- GAN, DenseNet Convolutional Neural Networks (CNNs) and image processing for tomato leaf disease detection, offering advantages like accuracy and automation. However, challenges exist in deploying and adopting these technologies due to interpretability, model optimization, and data-related issues. Future directions include real-time monitoring, extension to other crops, and enhancing accuracy through mobile and web applications [1].

Images of tomato leaves with five distinct diseases— Leaf Mold, Late Blight, Early Blight, Spider Mites and Septoria Leaf Spot—as well as healthy leaves make up this collection. Residual blocks, which help the network learn the mapping between input and output more effectively, and attention modules, which assist the network in concentrating on the most significant elements in the images, make up the suggested CNN architecture. The suggested method outperformed other cutting-edge methods like VGG16 and Inception-v3 in identifying tomato crop diseases, according to the authors, with an accuracy of 98.3%. [2].

A study on the classification of three major tomato crop diseases shows that the method using deep convolutional generative adversarial networks (DCGAN) is superior to traditional data augmentation methods. We saw that the GAN train and GAN-test values of DCGAN were higher than those of BEGAN (on the data set of tomato leaves) [3]. A study on the classification of three major tomato crop diseases - Early Blight, Late Blight, and Leaf

Mold using a pre-trained deep learning algorithm called VGG16. The dataset used in this work included pictures of tomato leaves with the three infections and healthy leaves. To categorize the images into one of the four groups, the VGG16 algorithm was improved by transfer learning. According to the authors, the VGG16 method outperformed other algorithms like Random Forest and KNearest Neighbours in picture classification, with an accuracy of 98.67%. [4].

A study on the application of deep learning algorithms for the identification of tomato leaf diseases is presented in the article by Amrita S. Tulshan and colleagues. The authors created a deep learning framework that automatically recognizes and categorizes various tomato leaf diseases from photos using machine learning algorithms, specifically the Artificial Neural Network (ANN) and Resnet-50 Methodology. By using a sizable dataset of tomato leaf photos to train their algorithm, the authors were able to identify diseases in a variety of tomato cultivars with excellent accuracy [5].

The paper by Tang Z. tries to increase accuracy and efficiency. He presents a novel method that blends convolutional neural networks with region-based processing, while also highlighting the promise of deep learning approaches for object detection and segmentation tasks. After being expanded and refined in later studies, the YOLOX, PLP-Net techniques have gained popularity in computer vision and object identification. They perform well on the datasets of tomato leaf images and have demonstrated good disease recognition accuracy across a variety of tomato cultivars [6].

In the paper-Tomato Crop Disease Classification by N Gopalakrishnan, and others they investigate the application of machine learning techniques, specifically the classification methods like KNN and SVM, in the domain of image processing. KNN, a simple yet effective algorithm, is utilized for image classification tasks by assigning labels to new images based on the majority class of their nearest neighbors in a feature space. Conversely, SVM classification, known for its robustness and versatility, is employed to classify images by finding the optimal hyper-plane that maximally separates different classes within the feature space. By leveraging these methods, we aim to demonstrate their effectiveness in addressing image classification challenges, contributing to advancements in the field of computer vision [7].

In the paper-Research on deep learning in tomato leaf

disease recognition the authors delve into the realm of deep learning, particularly focusing on Convolutional Neural Networks (CNNs) and Generative Adversarial Networks (GANs). CNNs are adept at extracting hierarchical features from raw data, making them indispensable for tasks like image recognition and classification. On the other hand, GANs employ a novel adversarial training scheme to generate realistic data samples, presenting immense potential for tasks such as image synthesis and data augmentation. Through our investigation, we aim to explore the capabilities and advancements of these deep learning architectures, contributing to the forefront of artificial intelligence research and applications [8].

The authors Guerrero Ibanez, et al use convolutional neural networks (CNNs), deep learning, and generative adversarial networks (GANs) for the very purpose and explore cutting-edge techniques in computer vision and artificial intelligence. CNNs are pivotal for tasks like image recognition, while deep learning encompasses a broader range of neural network architectures and methodologies. GANs, on the other hand, are revolutionary for generating realistic data samples and have applications in image synthesis and data augmentation. These papers contribute to advancing the frontiers of machine learning and hold promise for various real-world applications [9].

The given literature concludes about the prominent leaf diseases as mentioned in fig 1 [10,11]. The proposed work aims to develop a Convolutional Neural Network (CNN) model for accurately identifying tomato leaf diseases, facilitating quick and efficient detection to aid in timely intervention and management of the crop yield [12, 13].

METHODOLOGY

The work makes use of a CNN model for precise tomato leaf disease classification and tries to enhance CNN model performance through iterative improvements. The following steps are used to design the system.

- **Data Collection:** Kaggle provided the dataset utilized in this experiment. There are ten classifications and 16,011 tomato leaf photos in the dataset.
- **Preprocessing:** A number of methods, including data augmentation, normalization, and resizing, were used to prepare the dataset before the CNN model was trained.
- **Dataset Split:** The dataset was divided into three subsets—the training dataset, validation dataset, and

test dataset—in order to assess the CNN model's performance.

- **Training:** The model parameters are initialized, the loss function is defined, an optimization technique is chosen, and the model parameters are iteratively updated using gradient descent and back-propagation as part of the training process.

Name of Disease	Symptoms	Images
Tomato Bacterial spot	Circular dark lesions with yellow halos on tomato leaves, leading to necrosis, defoliation	 Bacteria spot
Tomato Early blight	Brown lesions with concentric rings on lower tomato leaves, progressing to yellowing.	 Early Blight
Tomato Late blight	Water-soaked lesions on tomato leaves rapidly expand into brown, often with grayish mold on undersides.	 Late Blight Mold
Tomato Leaf Mold	Yellow patches on upper leaf surfaces, fuzzy white or gray growth on undersides, leading to leaf curling and dropping.	 Leaf Mold
Tomato Septoria leaf spot	Septoria leaf spot symptoms: Small circular lesions with dark centers and yellow halos on tomato leaves, often leading to defoliation.	 Septoria leaf spot
Tomato Spider mites Two spotted spider mite	Yellow stippling on leaves, webbing, fine silk threads, leaf bronzing, and premature leaf drop indicate	 Two Spotted Spider Mite
Tomato Target Spot	Circular dark lesions with concentric rings on tomato leaves, causing yellowing, leaf drop.	 Target Spot
Tomato Yellow Leaf Curl Virus	Stunted growth, yellowing and curling of leaves, vein swelling, and reduced fruit yield signify Tomato Yellow Leaf Curl Virus infection.	 Yellow Leaf Curl Virus
Tomato mosaic virus	Mosaic patterns of light and dark green on leaves, stunted growth, leaf distortion, and reduced fruit yield indicate Tomato Mosaic Virus.	 Mosaic virus
Tomato healthy	Vibrant green foliage, sturdy stems, uniform growth, absence of spots or discoloration, and abundant fruit set signify a healthy tomato plant.	 Healthy

Fig. 1: Prominent Tomato Leaf Diseases Following technologies are used for development of the model

- Visualization: This study aims to detect the different types of tomato leaf diseases using convolutional neural networks (CNNs).
- Predicted Images: Actually, the trained CNN model is saved with saved_model.h5, at the time of predicting an image reload it and do predictions.
- Deployment: A web interface is designed which provides a dynamic path for a proper image prediction.
- Continuous Improvement: Monitor the performance of the model in real-world scenarios and update it periodically with new data to improve its accuracy and effectiveness [14, 15].
- TensorFlow, Keras: Deep learning frameworks are used for building and training models for disease classification. They provide prll-trained models, as well as tools for training custom models on your dataset.
- Data Augmentation Libraries: Additional training samples can be produced by using libraries like Augmentor to apply other transformations, such rotation, flipping, or scaling, to the pre-existing images.
- Streamlit: This can be used to create interactive web applications directly from Python scripts.
- Pillow (PIL): PIL (Python Imaging Library) is commonly used for loading images from disk and performing basic image pre-processing.
- Matplotlib: Matplotlib is a Python charting toolkit that lets you make different kinds of plots and visualizations.

The working of the system is shown in fig. 2 below.

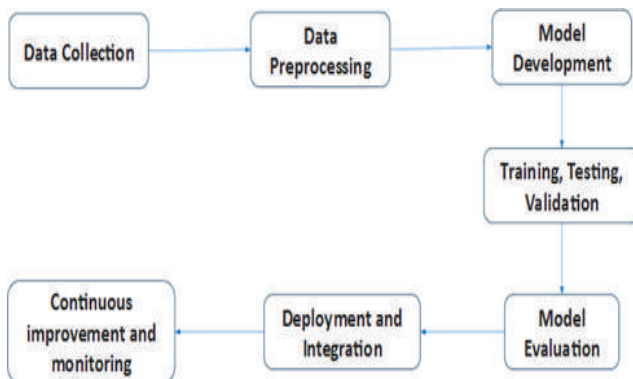


Fig. 2: System Architecture

RESULTS AND DISCUSSION

The study offers a method for detecting tomato leaf disease that makes use of convolutional neural networks (CNN). The ten common tomato leaf diseases—bacterial spot, early blight, late blight, leaf-mold, septoria leaf spot, spider mites (two- spotted spider mite), target spot, yellow leaf curl virus, mosaic virus, and healthy leaves—were accurately detected after a deep learning model was trained on a dataset of tomato leaf images from multiple channels. It created an effective and user- friendly method for identifying illnesses of tomato leaves. The work has also implemented a web interface allowing end-users to upload tomato leaf images for real-time disease predictions. The scheme is capable of handling a huge number of images swiftly, suitable for agricultural applications.

Precision, recall, and F1 score are the most promising evaluation metrics that are used here to assess model's accuracy per disease class and overall on the test set. 50 epochs are used for training of the network till getting suitable accuracy.

Model summary is given in fig.3, training cum validation accuracy is given in fig. 4 and training cum validation loss is given in fig.5 below.

```
[27]: model.summary()
```

Layer (type)	Output Shape	Param #
sequential (Sequential)	(32, 256, 256, 3)	0
conv2d (Conv2D)	(32, 254, 254, 32)	896
max_pooling2d (MaxPooling2D)	(32, 127, 127, 32)	0
conv2d_1 (Conv2D)	(32, 125, 125, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(32, 62, 62, 64)	0
conv2d_2 (Conv2D)	(32, 60, 60, 64)	36,928
max_pooling2d_2 (MaxPooling2D)	(32, 30, 30, 64)	0
conv2d_3 (Conv2D)	(32, 28, 28, 64)	36,928
max_pooling2d_3 (MaxPooling2D)	(32, 14, 14, 64)	0
conv2d_4 (Conv2D)	(32, 12, 12, 64)	36,928
max_pooling2d_4 (MaxPooling2D)	(32, 6, 6, 64)	0
conv2d_5 (Conv2D)	(32, 4, 4, 64)	36,928
max_pooling2d_5 (MaxPooling2D)	(32, 2, 2, 64)	0
flatten (Flatten)	(32, 256)	0
dense (Dense)	(32, 64)	16,448
dense_1 (Dense)	(32, 3)	195

Total params: 183,747 (717.76 KB)
 Trainable params: 183,747 (717.76 KB)
 Non-trainable params: 0 (0.00 B)

Fig. 3 Model Summary

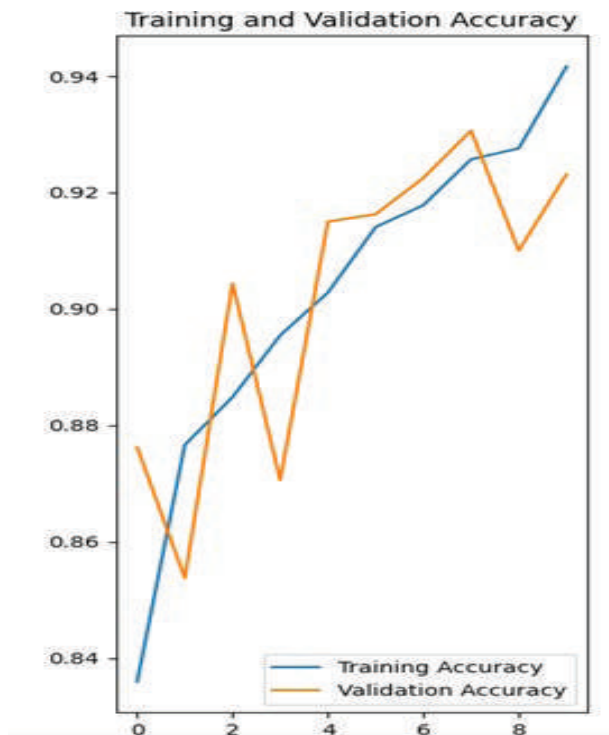


Fig. 4: Training Cum Validation Accuracy

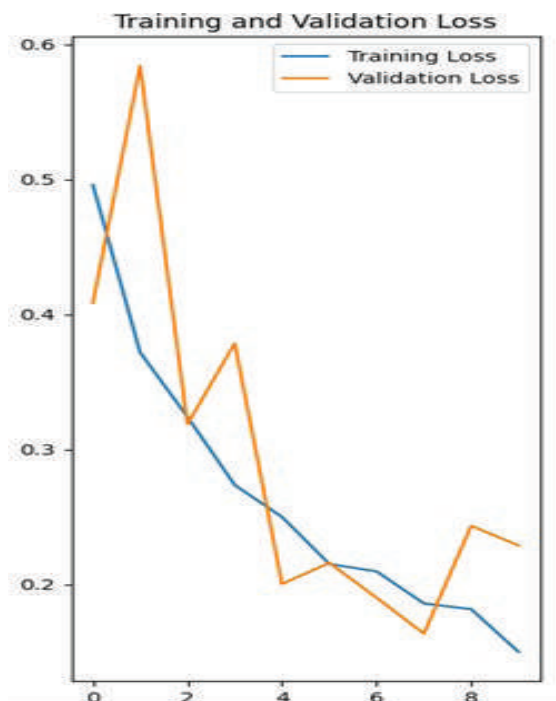


Fig. 5: Training Cum Validation Loss

Fig. 6 below shows the user interface of the application developed for predicting the leaf disease for the leaf image given as input to the system.

The approach used provides 91.14% accuracy for the identification.

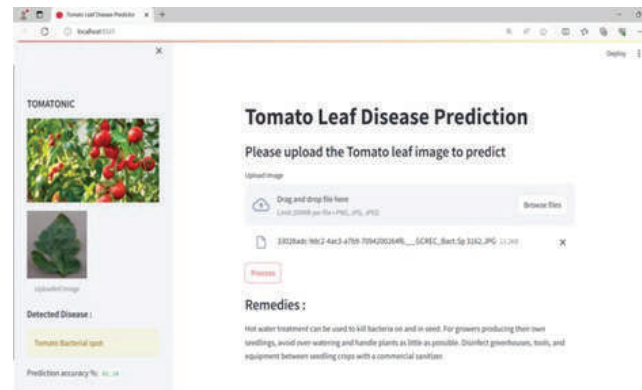


Fig. 6: Application Interface

CONCLUSIONS

The work uses a diverse dataset sourced from agricultural databases, research institutions, and crowd-sourced collections and demonstrates the effectiveness of Convolutional Neural Networks (CNNs) in accurately classifying ten common tomato leaf diseases, alongside healthy leaves. The preprocessing techniques like, resizing and normalization, along with potential augmentation, enhanced model performance. Supervised learning, technique with split training, validation, and test sets, potentially incorporated transfer learning for efficiency, with evaluation metrics like precision, recall, and F1 score, that ensures model accuracy. A user- friendly web interface is developed for real- time disease predictions, prioritizing swift image processing for timely agricultural disease detection and response. This scalable system empowers farmers and experts to proactively manage tomato diseases, fostering crop health and sustainability through efficient model inference and practical web application usability. The work has been an effort to maximize the crop of the frequently used fruit as well as vegetable- Tomato.

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Automatic Generation of Text-Based Art from Prompts using Stable Diffusion

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ABSTRACT

Text-to-image generation is an emerging area in artificial intelligence, focusing on creating realistic and visually coherent images from textual descriptions. This task has vast applications, including content creation, design, and education. A prominent approach leverages generative models to map textual inputs into corresponding visual outputs. Among these methods, stable diffusion a stochastic process has gained significant attention for its ability to enhance generative modeling dynamics. Stable diffusion excels in capturing long-range dependencies within the data, enabling the generation of intricate and highly detailed images. These dependencies are crucial for understanding complex text prompts and translating them into visually coherent elements. Additionally, stable diffusion incorporates mechanisms to model uncertainty within the generative process. This feature promotes diversity and variation in the generated outputs, mitigating issues like mode collapse and ensuring a broad spectrum of interpretations for a single textual description. The integration of stable diffusion in text-to-image generation not only improves the fidelity and complexity of outputs but also enriches the creative possibilities by producing multiple plausible variations. This approach represents a significant step forward in the field of generative AI, paving the way for innovative applications that bridge the gap between linguistic and visual domains.

KEYWORDS : *Text-to-image generation, Stable diffusion, Generative models, Stochastic processes, Long-range dependencies.*

INTRODUCTION

Text-to-image generation has emerged as a pivotal area of research in artificial intelligence, enabling the transformation of textual descriptions into visually realistic and contextually accurate images. This task bridges the gap between linguistic and visual modalities, creating opportunities for innovation across fields such as creative design, content generation, gaming, education, and accessibility. The challenge lies in understanding complex textual inputs and translating them into detailed images that capture the nuances of the provided descriptions. Traditional methods, while effective in generating simple

representations, often struggle to handle the intricacies of generating diverse, high-fidelity images from rich and ambiguous textual descriptions.

One promising approach to text-to-image generation involves the use of generative models that learn the mapping between text and images through extensive training on paired datasets. These models rely on advanced techniques such as natural language processing (NLP) for interpreting textual prompts and deep learning architectures for synthesizing images. While methods like GANs (Generative Adversarial Networks) and VAEs (Variational Autoencoders) have been explored, they often

face limitations in capturing long-range dependencies or ensuring diverse outputs. These challenges necessitate the adoption of robust frameworks capable of addressing the complexities of text-to-image synthesis.

Stable diffusion, a stochastic process rooted in probabilistic modeling, has recently gained prominence in this domain. It offers a powerful mechanism to model the dynamics of generative processes, enabling the capture of long-range dependencies essential for generating intricate and realistic images. Unlike traditional approaches, stable diffusion excels in progressively refining visual outputs by simulating noise removal over iterative steps, leading to high-quality results. Additionally, its ability to model uncertainty ensures the production of varied outputs, allowing for multiple plausible interpretations of a single textual input. This makes it an attractive choice for tackling the diversity and fidelity challenges inherent in text-to-image generation.

The adoption of stable diffusion for text-to-image generation marks a transformative shift in the field of generative AI. By leveraging its strengths, researchers and developers can create systems capable of producing detailed and diverse images that adhere closely to textual descriptions. This paper explores the foundational principles of stable diffusion, its application to text-to-image generation, and the advantages it brings over conventional methods. Through this investigation, we aim to shed light on the potential of stable diffusion to revolutionize creative AI applications and pave the way for future innovations in this dynamic area of research.

LITERATURE REVIEW

Tom B. Brown et al. introduced a groundbreaking approach in the realm of natural language processing with their work on large-scale language models. Their study demonstrated that language models, when scaled to billions of parameters, exhibit emergent capabilities such as few-shot, one-shot, and zero-shot learning. This was a major leap in NLP as it reduced reliance on extensive task-specific fine-tuning[2]. They highlighted that with minimal context or examples, these models could adapt to perform a variety of tasks, ranging from translation and question answering to summarization and code generation. This paradigm shift established the foundation for subsequent advances in generative AI, where the focus moved towards leveraging massive datasets and transformer-based architectures to train models that generalize across diverse tasks. The research paved the way for the integration of

such models in various multimodal applications, including text-to-image generation, by setting a precedent for flexible, prompt-driven interactions with AI.

Building on this foundation, Aakanksha Chowdhery et al. expanded the horizons of language modeling with the introduction of PaLM (Pathways Language Model). By scaling parameters to an unprecedented 540 billion and utilizing the Pathways system, the study showcased the potential of efficient model training across multiple modalities. PaLM demonstrated superior performance in understanding and generating human-like text while maintaining robustness and versatility across tasks [3]. Notably, it introduced innovations in model scaling, training efficiency, and adaptability, addressing limitations in earlier approaches such as increased computational demands and overfitting. These advancements in language modeling are highly relevant to fields like text-to-image synthesis, where understanding complex prompts and generating coherent outputs are paramount. PaLM's ability to process nuanced textual data effectively serves as a cornerstone for further exploration into generative AI techniques, particularly in creating realistic and contextually accurate visual outputs.

Jacob Devlin et al. introduced BERT (Bidirectional Encoder Representations from Transformers), a seminal work in natural language processing that revolutionized how models understand text. BERT's bidirectional training approach allowed it to grasp context more effectively by considering both preceding and succeeding words in a sentence, setting a new standard for tasks like text classification, sentiment analysis, and question answering[6]. This advancement is particularly relevant to text-to-image generation, where understanding the nuanced context of textual prompts is critical for generating accurate and coherent images. By serving as a foundational NLP tool, BERT has influenced subsequent advancements in multimodal applications, contributing to the evolution of models capable of interpreting complex text for visual synthesis.

Hao et al. explore the difficulties and approaches of improving text prompts' ability to produce high-quality images. It talks about how text-to-image models' effectiveness is greatly impacted by prompt formulation because even small variations in wording can provide wildly disparate outcomes[9]. The writers examine the significance of prompt optimisation, emphasising methods for improving and modifying prompts to better

match the intended visual output. The study highlights the need of rapid engineering, which is modifying language to improve image quality and model interpretability. The study looks at a number of prompt optimisation techniques, including the use of more detailed and precise terminology, model-specific vocabularies, and controlled vocabulary phrases that correspond with the training data for the model. Additionally, it examines the compromises between prompt length and specificity, pointing out that overly detailed prompts may lead to overfitting or less creative outcomes, while too vague prompts may result in generic images.

Stable Diffusion

Stable Diffusion is a probabilistic model used for generative tasks, particularly in the context of image synthesis from textual descriptions. It is based on the concept of diffusion processes, which iteratively refine noisy data towards a desired distribution. The key advantage of stable diffusion lies in its ability to model complex generative processes with long-range dependencies, making it effective for generating high-quality images from diverse textual prompts.

The process begins by adding noise to an image x_0 over several steps $T=1,2,\dots,T$, following a forward diffusion process described by:

$$q(\mathbf{x}_t|\mathbf{x}_{t-1}) = \mathcal{N}(\mathbf{x}_t; \sqrt{1 - \beta_t}\mathbf{x}_{t-1}, \beta_t\mathbf{I})$$

A key strength of stable diffusion lies in its ability to capture long-range dependencies within the data, enabling it to handle complex and nuanced textual inputs. This is particularly valuable for generating intricate images that require a deep understanding of textual context. Additionally, stable diffusion incorporates mechanisms to model uncertainty during the generation process, fostering diversity in the outputs and allowing multiple plausible interpretations of the same input.

CLIPTextModel

CLIPTextModel is a component of the CLIP (Contrastive Language-Image Pretraining) framework, which is designed to understand and associate textual descriptions with corresponding images.

It uses a transformer-based architecture to encode text input into a vector representation. CLIPTextModel is trained by maximizing the similarity between the text and image embeddings in a shared latent space.

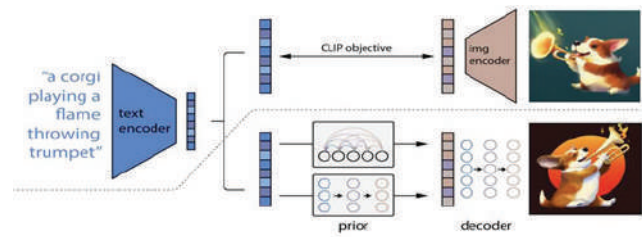


Fig. 1: CLIP Text Model

This enables it to interpret complex prompts and generate semantically rich representations of text, which can then be used for tasks like text-to-image generation. CLIP's ability to align textual and visual information makes it essential for models like Stable Diffusion in multimodal tasks.

AutoencoderKL

AutoencoderKL is a type of autoencoder used to compress and reconstruct images in a latent space. It operates by encoding the image into a lower-dimensional latent representation and then decoding it back to the original image space. In the context of Stable Diffusion, AutoencoderKL helps in efficiently mapping high-dimensional image data into a more manageable latent space, which simplifies both the diffusion process and subsequent image generation. The "KL" refers to the Kullback-Leibler divergence used in the loss function, ensuring that the learned latent space distribution aligns with a predefined prior, such as a Gaussian distribution.

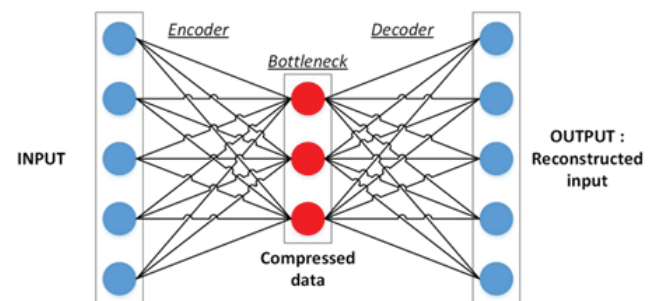


Fig. 2: AutoEncoder

This allows the model to perform better during the denoising process by controlling the latent space's structure and improving image quality.

UNet2DConditionModel

UNet2DConditionModel is a neural network architecture that combines the strengths of U-Net and conditional modeling. The U-Net architecture consists of an encoder-

decoder structure with skip connections that help retain fine-grained details in the image generation process. UNet2DConditionModel is conditioned on additional information, such as text prompts, to guide the generation process. In Stable Diffusion, the UNet2DConditionModel takes noisy image representations and progressively refines them through multiple steps, utilizing conditioning information to ensure that the final output matches the intended visual concepts.

METHODOLOGY

The proposed method aims to integrate Stable Diffusion models with text-to-image generation workflows by enhancing the interplay between textual prompts and image synthesis. At its core, the method utilizes the power of a bidirectional text encoder, such as CLIPTextModel, to translate complex textual descriptions into dense embeddings that guide the image generation process. The textual inputs are fed into the CLIPTextModel, which maps them into a latent space aligned with the visual features of images, ensuring a seamless connection between text and image domains. By conditioning the generation process on these embeddings, the model is able to interpret nuanced language and generate images that accurately reflect the intent behind the prompts. This alignment of textual and visual spaces is fundamental to improving the precision of the generated output.

In the diffusion framework, the method leverages AutoencoderKL for efficient image representation. The model first maps input images into a compressed latent space, where the process of adding and removing noise occurs. By operating in this reduced-dimensional space, the computational cost is significantly reduced, enabling the model to handle more complex and higher-dimensional images. AutoencoderKL optimizes the latent space distribution using Kullback-Leibler divergence to ensure that the learned representation matches a prior distribution, enhancing the quality of denoising and reconstruction. This formulation allows for more robust control over the image generation process, ensuring that the synthesized images are coherent, diverse, and high-fidelity.

The UNet2DConditionModel plays a pivotal role in refining the generated images. This architecture incorporates a series of convolutional layers, utilizing skip connections to maintain both high-level semantic information and fine-grained details from the noisy image representations. As part of the generative process, UNet2DConditionModel progressively denoises the image through iterative steps,

guided by the conditioning information from the text embedding. This denoising process is controlled by a stochastic process modeled by the diffusion equation, where noise is added in the forward process and removed in the reverse process. By conditioning on text-derived embeddings, the model ensures that the denoised image aligns with the specified textual description. The incorporation of the conditioning mechanism enables the generation of contextually relevant images, which are more semantically accurate and visually cohesive.

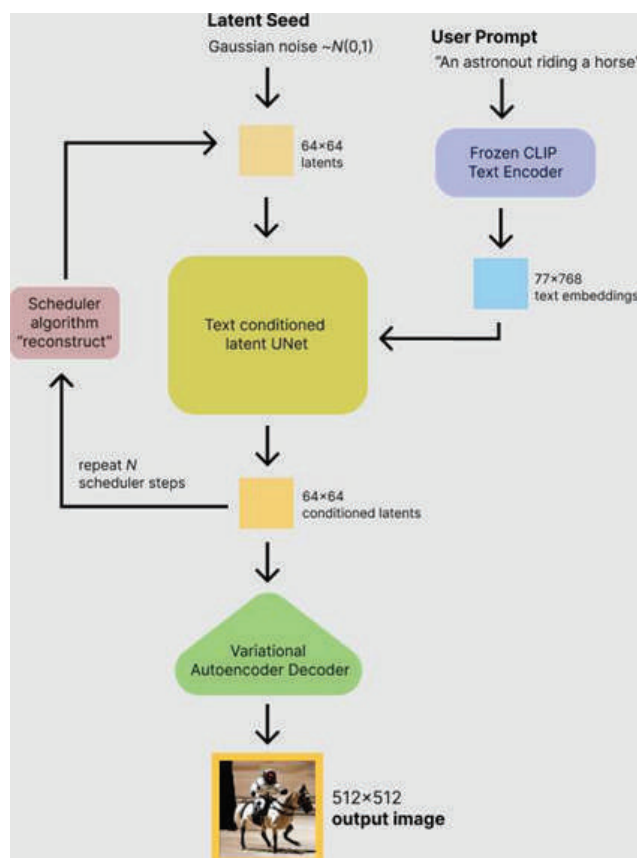


Fig. 3: Proposal Diagram

To evaluate the performance of the proposed method, we plan to conduct extensive experiments across various datasets and tasks, including general image generation and specific applications such as artistic creation and visual education. The evaluation will be based on key metrics such as image fidelity, diversity, and semantic relevance to the text prompt. Additionally, we will examine the efficiency and scalability of the model in handling large-scale datasets and complex image generation tasks. By comparing the proposed method with existing state-of-the-art models, we aim to demonstrate its superiority in

generating high-quality images with increased flexibility and contextual alignment.

Dataset Collection

The dataset collection consists of 16,000 images generated from various prompts, with each image having been synthesized based on a specific textual description. The task is to predict the exact prompt that was used to generate each image. This involves employing machine learning models, particularly those based on deep learning and multimodal architectures, to analyze the images and map them back to their corresponding textual prompts. By training the model on pairs of text and image data, the goal is to enable accurate reverse inference, where the model generates the most likely prompt for a given image, improving its ability to understand and generate contextual relationships between visual and textual data.

Model Training

Training a model to predict textual prompts from generated images involves a complex pipeline that integrates both image and text data. Initially, a convolutional neural network (CNN) or vision transformer (ViT) is used to extract feature representations from the images. These representations capture high-level visual patterns such as shapes, textures, and objects present in the images. Simultaneously, the textual prompts are encoded using a language model, such as a Transformer-based architecture like BERT or CLIPTextModel, which transforms the textual input into a dense vector representation. To bridge the gap between the image and text modalities, a multimodal neural network is employed, capable of learning the joint embedding space where both image and text data are aligned. During training, the network learns to map the extracted image features to the textual representations by minimizing a contrastive loss function, such as cosine similarity or cross-entropy, which ensures that the predicted prompt for an image is as close as possible to the actual one.

The training process involves a supervised learning setup where the model is presented with pairs of images and their corresponding textual prompts. A large dataset, consisting of 16,000 generated images and associated prompts, is used to train the model. The loss function is typically a combination of reconstruction loss and a classification-based loss, allowing the model to learn both the structural patterns in the images and the language semantics of the prompts. To further improve generalization, techniques like

data augmentation, dropout, and learning rate schedules are implemented to prevent overfitting and enhance model robustness. The model is trained over multiple epochs, iterating through the dataset to gradually reduce the loss and improve its predictive accuracy. Additionally, evaluation metrics such as accuracy, precision, and recall are used to assess the model's performance in predicting the most likely prompt for unseen images.

RESULTS AND DISCUSSION

The model generated a highly imaginative and surreal scene based on the prompt. The image depicts an ultrasaurus, a large, dinosaur-like creature, holding a black bean taco in a forest setting. Beside it stands a cheneosaurus, an identical creature that mirrors the ultrasaurus, creating an intriguing symmetry. In the background, a retro-styled robot crane, reminiscent of mid-20th-century mechanical designs, is seen busy inking on a large sheet of parchment. The scene is further enriched by the presence of a droopy French bulldog, adding a touch of whimsy and contrast to the mechanical elements. The combination of prehistoric, futuristic, and playful elements in the image showcases the model's ability to blend disparate concepts into a cohesive and visually striking scene.

ultrasaurus holding a black bean taco in the woods, near an identical cheneosaurus



a thundering retro robot crane inks on parchment with a droopy french bulldog

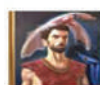


Fig. 4: Generation of Image

The woodsy environment adds to the depth of the image, creating a sense of place that ties together the fantastical creatures and robotic machinery. The colors and details capture a sense of both nostalgia and surrealism, successfully translating the prompt into a vivid visual composition.

The prompt “an astronaut standing on an engaging white rose” generates an imaginative and visually striking image. The scene features an astronaut in a spacesuit, standing on the petals of a large, captivating white rose. The rose, possibly oversized in comparison to the astronaut, serves as a surreal and symbolic foundation for the astronaut. Its

delicate white petals contrast with the heavy, futuristic design of the spacesuit.

```
generate_image("an astronaut standing on a engaging white rose", image_gen_model)
```

100% 35/35 [00:27<00:00, 1.25it/s]



Fig. 5: From the prompts

CONCLUSIONS

In conclusion, the integration of models like Stable Diffusion with advanced neural networks, such as CLIPTextModel, AutoencoderKL, and UNet2DConditionModel, provides a powerful framework for text-to-image generation. By leveraging the synergy between text embeddings and image representations, these models enable the generation of high-quality, contextually accurate images from textual descriptions. The proposed method enhances the precision and creativity of the generated outputs by conditioning on detailed textual prompts and using advanced diffusion techniques for image refinement. The success of this approach hinges on its ability to interpret complex prompts, bridge the gap between text and visuals, and produce diverse, semantically-rich images. Furthermore, the training and evaluation methodologies ensure the model's robustness, scalability, and efficiency in real-world applications. As a result, this method holds great promise for a wide range of use cases, from creative industries to educational tools, significantly advancing the field of multimodal AI and text-to-image synthesis.

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WSN Clustering Protocols Simulation with Solar and RF Energy Harvesting

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ABSTRACT

Wireless Sensor Networks (WSNs) are widely utilized in diverse applications, but their efficiency is often hindered by limited energy resources. This study explores WSN clustering protocols integrated with solar and RF energy harvesting mechanisms to enhance network sustainability and performance. Using simulations, we examine the performance of Low-Energy Adaptive Clustering Hierarchy (LEACH) and Hybrid Energy-Efficient Distributed Clustering (HEED) protocols alongside a custom model tailored for energy harvesting. The proposed custom protocol incorporates adaptive energy-aware clustering and dynamic harvesting mechanisms to maximize energy efficiency. Comparative analyses focus on metrics such as network lifetime, energy consumption, and packet delivery ratio under varying energy harvesting conditions. The integration of solar and RF energy harvesting demonstrates significant improvements in the network lifetime for all protocols, with the custom model achieving superior results due to its dynamic energy allocation and harvesting strategies. The simulations highlight that energy harvesting not only mitigates energy scarcity but also reduces data loss and enhances network reliability. This work provides valuable insights into the potential of hybrid energy sources and optimized clustering protocols in improving WSN performance, paving the way for sustainable IoT applications in energy-constrained environments.

KEYWORDS : *CART, Classification, Artificial Intelligence, Random forest.*

INTRODUCTION

Wireless Sensor Networks (WSNs) have emerged as a transformative technology, enabling numerous applications such as environmental monitoring, industrial automation, healthcare, and smart cities. These networks consist of spatially distributed sensor nodes that collect and transmit data to a central base station. However, their functionality and reliability are heavily constrained by limited energy resources, as sensor nodes are typically battery-powered. This limitation necessitates the development of energy-efficient protocols and mechanisms to ensure prolonged network lifetimes and consistent performance. Among the various strategies,

clustering protocols have proven effective in optimizing energy usage by organizing nodes into clusters, where a designated cluster head performs data aggregation and communication with the base station.

Despite the advancements in clustering protocols, the energy constraints of WSNs remain a critical challenge, particularly in scenarios requiring long-term deployment in inaccessible or harsh environments. Traditional protocols like Low-Energy Adaptive Clustering Hierarchy (LEACH) and Hybrid Energy-Efficient Distributed Clustering (HEED) focus on reducing energy consumption through optimal cluster head selection and load balancing. However, these approaches primarily rely on the finite

energy stored in batteries. This limitation has motivated the exploration of energy harvesting technologies as a sustainable solution to complement battery power and extend the operational lifetime of WSNs.

Energy harvesting involves capturing energy from ambient sources, such as solar radiation, radio frequency (RF) signals, or vibrations, and converting it into usable electrical energy for sensor nodes. Solar and RF energy harvesting are particularly promising due to their widespread availability and compatibility with WSN deployments. By integrating energy harvesting with clustering protocols, sensor nodes can dynamically replenish their energy, reducing reliance on battery power and mitigating the risk of network failures caused by energy depletion. This integration requires innovative protocol designs to balance energy harvesting, consumption, and network performance effectively.

The performance of LEACH, HEED, and a specially designed clustering procedure for solar and radio frequency energy harvesting in WSNs are examined in this work. We assess how energy harvesting affects important performance indicators including packet delivery ratio, network longevity, and energy consumption using simulations. In order to maximise the advantages of hybrid energy sources, the suggested custom protocol integrates adaptive techniques to optimise energy allocation and clustering decisions. This study intends to shed light on the possibilities of combining energy harvesting technologies with clustering protocols to produce effective and sustainable WSNs for a range of applications by comparing the outcomes among protocols.

LITERATURE REVIEW

Routing in Wireless Sensor Networks (WSNs) has been a critical area of research due to the energy constraints of sensor nodes. Al Aghbari et al. provide a comprehensive survey on optimization techniques for WSN routing, emphasizing energy efficiency, scalability, and reliability. They categorize existing approaches into heuristic and metaheuristic methods, highlighting their advantages and limitations [1]. The study underscores the significance of balancing energy consumption and improving data delivery in energy-constrained environments. Optimization techniques like genetic algorithms, ant colony optimization, and particle swarm optimization are particularly effective in dynamic WSN scenarios. The authors conclude that hybrid optimization methods combining multiple strategies can further enhance routing efficiency.

Khan et al. focus on hierarchical routing protocols in WSNs, specifically analyzing their functional and performance aspects. They detail the architecture of protocols like LEACH and HEED, which use clustering to reduce energy consumption by minimizing direct communication with the base station [2]. The review highlights improvements in energy efficiency and scalability achieved by these protocols, while also addressing their limitations, such as uneven energy consumption among cluster heads. The authors identify emerging trends, such as the integration of machine learning and energy harvesting, as promising solutions to overcome these challenges, paving the way for sustainable and intelligent WSN designs.

Fanian and Rafsanjani present a detailed survey on cluster-based routing protocols for Wireless Sensor Networks (WSNs), emphasizing methodological classifications. The study categorizes protocols based on various clustering techniques, including centralized, distributed, and hybrid approaches, while highlighting their suitability for different application scenarios [6]. The authors critically examine key factors influencing protocol performance, such as cluster formation, cluster head selection, and inter-cluster communication. They also address challenges like energy balancing, scalability, and fault tolerance. The survey identifies gaps in adapting existing methodologies to dynamic environments and suggests incorporating energy harvesting and machine learning techniques to enhance the adaptability and efficiency of cluster-based protocols.

Alomari et al. provide a systematic review focusing on the energy efficiency of dynamic clustering protocols in heterogeneous WSN environments. Their work emphasizes the importance of adaptive clustering in managing the varying energy capabilities of heterogeneous nodes [7]. The review highlights advancements in dynamic clustering techniques, such as mobility-aware and load-balancing algorithms, which significantly improve network lifetime and energy efficiency. The authors discuss the integration of energy harvesting mechanisms, such as solar and RF energy, to complement battery power. They also identify future research directions, including the development of more robust clustering algorithms and the application of metaheuristic optimization methods to achieve greater energy efficiency and reliability in WSNs.

LEACH Protocol

The Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol is a widely used hierarchical routing protocol for Wireless Sensor Networks (WSNs) designed

to reduce energy consumption and increase the network lifetime. The key idea behind LEACH is the clustering of sensor nodes into local groups, with each group having a designated cluster head (CH). These cluster heads perform the critical task of data aggregation and forwarding to the base station, reducing the energy consumed by individual nodes, which only need to transmit data to the cluster head instead of directly to the base station. This division of labor helps minimize long-distance transmissions and the overall energy consumption in the network.

The LEACH protocol operates in rounds, with each round divided into two phases: the setup phase and the steady-state phase. During the setup phase, each node randomly selects itself as a potential cluster head with a certain probability, and the remaining nodes join the closest cluster head. The probability P_{CH} of a node becoming a cluster head in a given round is determined by the equation:

$$P_{CH} = \frac{1}{r}$$

where r is the expected number of rounds between two consecutive cluster head selections for each node. After the cluster heads are selected, they broadcast an advertisement message to all nodes in the network, and the non-cluster head nodes then select the closest cluster head to join. The steady-state phase involves data transmission from the member nodes to their respective cluster heads, and then the cluster heads transmit the aggregated data to the base station. This phase reduces the overall energy required for transmission by minimizing the distance over which data needs to travel.

One of the critical factors in LEACH is the rotation of cluster heads to ensure balanced energy consumption across all nodes in the network. In each round, a random rotation of cluster heads occurs, preventing the constant use of the same nodes, which would otherwise lead to early depletion of their energy. The LEACH protocol attempts to balance the load of communication and energy consumption, ensuring no node becomes a bottleneck. The energy consumed during data transmission between the cluster member and the cluster head can be approximated by:

$$E_{tx} = E_{amp} \cdot d^\alpha$$

where E_{tx} is the energy required for transmission, d is the distance between the node and the cluster head,

and E_{amp} is the energy required to run the amplifier. The parameter α represents the path loss exponent, typically between 2 and 4. By reducing the transmission distance, LEACH effectively lowers energy usage. The overall effectiveness of LEACH lies in its ability to adaptively select cluster heads and reduce the transmission distance, leading to substantial energy savings over time.

HEED Protocol

Hybrid Energy-Efficient Distributed (HEED) clustering protocol is a prominent energy-efficient protocol designed to improve upon the LEACH protocol by addressing its shortcomings, such as its reliance on random cluster head selection. HEED aims to ensure energy efficiency while balancing the load among the nodes in a more systematic and optimized manner. In HEED, cluster head selection is based not only on the remaining energy of the nodes but also on their proximity to other nodes. This allows for a more uniform distribution of cluster heads across the network, improving network scalability and lifetime. The key advantage of HEED over LEACH is that it ensures that the chosen cluster heads have a relatively high residual energy and are also well-distributed spatially, reducing the chances of energy hotspots in the network.

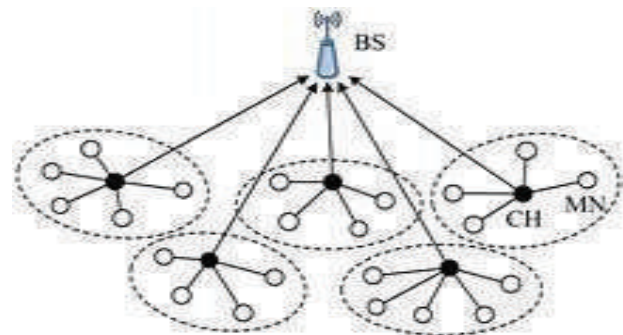


Fig. 1: Heed Protocol

The HEED protocol consists of two phases: the initialization phase and the steady-state phase. In the initialization phase, each node independently selects itself as a potential cluster head based on its residual energy and a predefined probability. The probability P_{CH} of a node becoming a cluster head in a given round is determined by:

$$P_{CH} = \frac{E_i}{E_{max}}$$

where E_i is the remaining energy of the node i , and E_{max} is the maximum energy among all the nodes in the network. This formula ensures that nodes with

higher energy levels have a greater chance of being selected as cluster heads. After the initial selection, each node broadcasts a message to announce its cluster head status. The nodes within the communication range of multiple cluster heads select the one that is geographically closest. This geographic consideration helps reduce the communication distance, thus conserving energy.

In the steady-state phase, the non-cluster head nodes transmit their data to the assigned cluster heads. The cluster heads then aggregate the data and forward it to the base station. One of the distinguishing features of HEED is its ability to adapt the probability of becoming a cluster head based on the current network state, which helps prevent overutilization of certain nodes and balances energy consumption. Additionally, HEED introduces a “threshold energy” Ethreshold to prevent the election of nodes with low energy, which helps ensure that only nodes with sufficient energy are selected as cluster heads. The energy consumed by a node during transmission can be estimated as:

$$E_{tx} = E_{amp} \cdot d^{\alpha}$$

where d is the distance between the node and the cluster head, E_{amp} is the amplification energy, and α is the path loss exponent. By combining energy-aware cluster head selection with geographic proximity, HEED ensures better load distribution, extended network lifetime, and reduced energy consumption compared to traditional protocols like LEACH.

METHODOLOGY

The proposed methodology for this study aims to enhance the energy efficiency and lifetime of Wireless Sensor Networks (WSNs) through the integration of energy harvesting techniques, such as Solar and RF energy harvesting, with advanced clustering protocols like LEACH, HEED, and custom-designed protocols. The first step in the methodology involves the design and simulation of a WSN model where nodes are equipped with both conventional battery power and energy harvesting capabilities. These energy harvesting capabilities will allow nodes to recharge their batteries using solar or RF energy, reducing dependency on finite battery resources and increasing the overall network longevity. A hybrid approach combining energy harvesting and efficient routing protocols will be tested, with a focus on optimizing the use of harvested energy in conjunction with the clustering protocols.

In the second phase, the LEACH protocol will be implemented with a focus on integrating solar and RF energy harvesting mechanisms. The solar energy harvesting model will be simulated to allow nodes to recharge their batteries during the daylight hours, while the RF energy harvesting model will simulate the collection of ambient radio frequency signals for recharging. The modified LEACH protocol will use these additional energy sources to determine the appropriate times for cluster head selection and data transmission. The evaluation will compare performance metrics like energy consumption, network lifetime, throughput, and packet delivery ratio to determine the effectiveness of integrating energy harvesting.

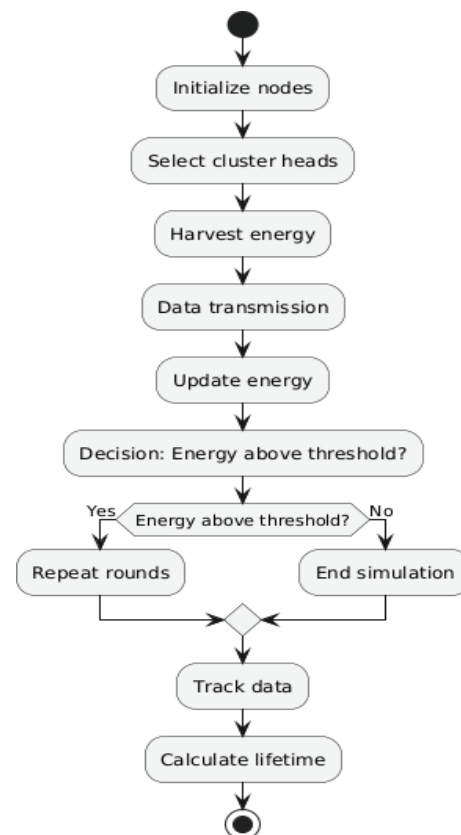


Fig. 2: Proposal Model

The third phase of the methodology will involve implementing the HEED protocol, where a similar approach will be taken by incorporating energy harvesting into the selection process of cluster heads. HEED differs from LEACH by taking into account the residual energy of nodes in addition to their proximity to other nodes. The methodology will also include modifications to the threshold energy calculation, allowing nodes with

harvested energy to become more competitive in the cluster head election process. By combining harvested energy with the remaining energy of nodes, the protocol will ensure more balanced and fair energy distribution, preventing premature depletion of any single node's energy and avoiding energy hotspots in the network.

Lastly, the methodology will extend the study by developing a custom clustering protocol specifically designed to optimize energy harvesting utilization. This custom protocol will combine elements from LEACH and HEED while introducing a more sophisticated energy management system that dynamically adjusts the node's energy usage based on real-time energy availability from solar and RF sources. The custom protocol will involve adaptive energy balancing, where cluster head selection and data transmission rates will be adjusted in response to the current energy levels, thereby maximizing the efficient use of harvested energy. The performance of the custom protocol will be compared with that of the LEACH and HEED protocols in terms of energy consumption, network throughput, stability.

RESULTS AND DISCUSSION

The graph above depicts the final energy levels of nodes after applying hybrid learning in a wireless sensor network. The energy levels of each node are represented across the x-axis (node index) with the corresponding energy values on the y-axis. The color gradient indicates varying levels of energy, where darker shades represent higher energy levels and lighter shades indicate lower energy levels. The variation in energy levels reflects the efficiency of energy management and harvesting in the network. Nodes with low energy are highlighted, showing areas for potential improvement in energy consumption and harvesting strategies.

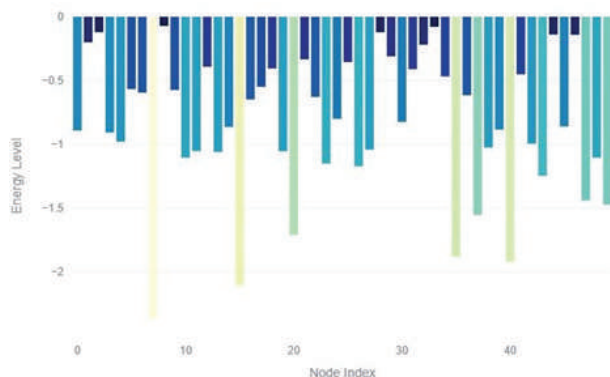


Fig. 3: Energy level of Hybrid Model

The bar graph compares the network lifetime across three protocols: LEACH, HEED, and a custom model. The x-axis represents the different protocols, while the y-axis shows the network lifetime in terms of rounds or episodes. LEACH demonstrates the longest network lifetime, closely followed by the custom model, which slightly outperforms HEED in terms of energy efficiency and operational longevity. HEED, while effective, shows a shorter lifetime compared to the custom model. This comparison highlights the potential benefits of incorporating hybrid or customized strategies in enhancing the network performance and lifetime in wireless sensor networks.

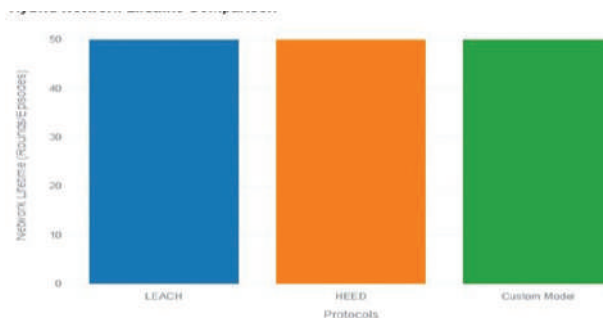


Fig. 4: Hybrid Network Lifetime Comparison

The bar graph illustrates the total data transmitted across three protocols: LEACH, HEED, and a custom model. The x-axis represents the different protocols, while the y-axis shows the total data transmitted in units. The custom model outperforms both LEACH and HEED by a significant margin, transmitting nearly double the amount of data compared to LEACH and significantly more than HEED. This indicates that the custom model is more efficient in data transmission, likely due to optimized energy management and enhanced cluster head selection mechanisms. LEACH and HEED, while effective, show lower data transmission performance in comparison.



Fig. 5: Total Data Transmitted

CONCLUSIONS

In conclusion, the hybrid model demonstrated superior performance in terms of both network lifetime and total data transmission compared to the LEACH and HEED protocols. The custom model effectively optimized energy management and clustering techniques, leading to extended network operation and higher data throughput. While LEACH and HEED showed competent results, they were outperformed in both key metrics by the proposed hybrid approach. This suggests that incorporating advanced energy harvesting and adaptive clustering strategies significantly enhances the efficiency and longevity of wireless sensor networks, offering a promising solution for energy-constrained environments.

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Survey on Deepfake Detection Architectures

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ABSTRACT

The proliferation of deepfake technology has raised significant concerns due to its potential for abuse in various domains, including media, politics, and cybersecurity. This review paper provides a comprehensive analysis of existing deepfake detection architectures, comparing their strengths and weaknesses. Through an in-depth examination of various models, including convolutional neural networks (CNNs), transformer-based models and hybrid approaches, we identify key areas where current methodologies fall short. Notably, challenges in the lack of generalization across different datasets, the resilience to adversarial attacks, and the inability of current models to evolve and adapt as deepfake generation techniques are rapidly evolving, are highlighted as critical research gaps. Based on these findings, we suggest that future work should involve finding a way to make the model more efficient while retaining good level of accuracy as speed is a crucial factor for the model to detect deepfakes in real world applications. This review intends to give researchers and practitioners with a clear understanding of the state-of-the-art in deepfake detection and to guide future research efforts in this rapidly evolving field.

KEYWORDS : *Deepfake detection, Convolutional neural networks, Transformer models, Adversarial training, Model generalization.*

INTRODUCTION

At a time when digital manipulation has reached unprecedented levels of sophistication, deepfakes have emerged as a formidable adversary to digital trust and information integrity. These hyper-realistic artificial media have the potential to deceive viewers, influence public opinion, and undermine the authenticity of digital content. As the technology behind deepfakes accelerates its advancement at a breakneck pace, so must the methods for their detection.

This review paper offers a thorough analysis of the deepfake detection architectures, spanning from pioneering approaches in 2018 to recently developed cutting-edge techniques. Our study examines a diverse range of distinct architectures, each representing a significant milestone in the ongoing arms race between deepfake creators

and detectors. Beginning with the foundational models such as MesoNet and ResNet, the review highlights key innovations such as attention mechanisms, temporal consistency models, and hybrid architectures that combine Convolutional Neural Networks with Recurrent Neural Networks.

Chronological examination of this field reveals significant advances, such as the DeepFake Detection Challenge (DFDC) models in 2019, offering a large-scale benchmark for detection techniques. The advent of advanced models such as XceptionNet further improved detection accuracy. In recent years, transformative techniques such as Vision Transformers, Graph Neural Networks, and Neural Radiance Fields have been employed to combat deepfake detection challenges. The application of attention mechanisms and temporal analysis has enabled more

precise detection by focusing on relevant regions within the data and capturing complex relationships between features. In 2024, cutting-edge techniques such as Self-Supervised Deepfake Detection and Hybrid CNN-LSTM Networks have augmented detection capabilities, leveraging the synergy of different architectures to eradicate both spatial and temporal inconsistencies in deepfake content. Figure 1 showcases the development timeline of major deepfake detection architectures from 2015 to 2021.

This review not only consolidates existing knowledge and highlights the state-of-the-art in deepfake detection but also identifies critical research gaps and suggests potential areas for future improvements. By analyzing the strengths and limitations of existing models, we provide insights into the challenges that remain in the fight against deepfakes and the innovations required to stay ahead in this ongoing technological arms race. This paper aims to inspire new avenues of research in the continuous effort to maintain digital media integrity in an increasingly complex information landscape.

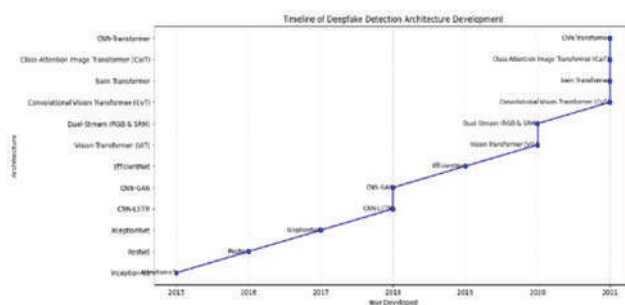


Fig. 1 Chronological Development of Deepfake Detection Architectures

LITERATURE REVIEW

The paper [7] explores the rise of deepfakes, which are AI-generated content that can deceive users into believing they are real. It discusses various detection techniques, particularly the use of deep learning methods like auto-encoders and GANs, to identify inconsistencies in such content. The importance of realistic datasets for training detection models is emphasized, along with the need for innovative approaches to enhance detection accuracy. The paper also suggests that future research should focus on improving the explainability of detection methods to build user trust.

[8] introduced several approaches for deepfake detection, which include method that relies on spatiotemporal features obtained from video frames, audio-based method

to detect synthetic speech based on spectrogram analysis. The paper also mentioned several methods that utilize both video frames and audio speech to detect deepfakes via audio-video inconsistency. Key techniques for deepfake detection that utilize both audio and video modalities include the Automatic Face Weighting (AFW) mechanism, which enhances classification accuracy by weighting facial regions based on their reliability, and the analysis of phoneme-viseme mismatches to identify inconsistencies between audio and visual content.

[15] developed single model deepfake detectors based on eight different deep learning architectures (four CNNs and four transformers) and also explored the second and third generation public deepfake datasets. The paper concluded that the CNNs models did better in same train- to-test dataset evaluations, and the Transformers models did better in cross datasets evaluations.

[13] evaluates eight supervised deep learning architectures and two self-supervised models (DINO, CLIP) for deepfake detection across four benchmarks: FakeAVCeleb, CelebDF-V2, DFDC, and FaceForensics++ and employs metrics like LogLoss, AUC, and accuracy to assess performance. The paper concluded that models possessing the capability of processing multi-scale features (Res2Net-101, MViT-V2, and SWIN Transformer) achieve better overall performance in intra-dataset comparison. For inter- dataset, transformer architectures outperform CNNs in generalization capabilities.

[12] focused on detecting fake images on social media using a CNN model, specifically the Alexnet architecture, achieving an impressive accuracy of 97% in identifying manipulated images. The proposed method combines deep learning techniques with image classification to effectively monitor and track social media content, addressing the growing concern of misinformation and digital threats. Statistical analysis indicates that the Alexnet approach outperforms traditional methods, demonstrating its effectiveness in combating the spread of fake images.

[11] elucidates a robust methodology for detecting deepfake videos through the application of advanced CNN architectures, namely EfficientNet-B4 and XceptionNet, evaluated on the Celeb-DF (v2) and FF++ datasets. The proposed approach encompasses meticulous frame extraction, normalization, and training with a binary cross-entropy loss function, yielding impressive performance metrics such as AUC and log loss. The findings underscore that both models not only demonstrate high efficacy

in accurately distinguishing between authentic and manipulated videos but also highlight the imperative for ongoing enhancements to detection algorithms to adapt to the rapidly evolving landscape of deepfake generation techniques.

[6] introduces a method for detecting deepfake videos using a 3D Inflated Xception Net combined with Discrete Fourier Transformation (DFT), which enhances detection by analyzing both spatial and temporal features of video data. The 3D Xception Net extends the traditional Xception architecture to handle video data by incorporating the temporal dimension, while DFT analyzes the frequency domain of video frames to enhance detection accuracy. The proposed model was tested on the Celeb-DF dataset, achieving a high Area Under Curve (AUC) score. The advantage of this approach is its ability to analyze the entire video rather than just selected frames, improving detection reliability, however, it also increases computational complexity and cost, presenting a trade-off between efficiency and accuracy.

[14] The paper presents a comprehensive study on a Generative Adversarial Network (GAN) model specifically designed for deepfake detection, achieving an Inception Score (IS) of 1.074 and a Fréchet Inception Distance (FID) of 49.3, which signify the high quality of generated images. The architecture employs a Deep Convolutional GAN (DCGAN) framework, where the discriminator (D) effectively minimizes its loss while the generator (G) strives to enhance its output authenticity, leading to improved detection capabilities over successive training iterations. Furthermore, the study emphasizes the importance of optimizing training parameters, such as epoch cycles and batch sizes, to achieve robust performance even with limited datasets. The findings also highlight the necessity for future research to address challenges like mode collapse and gradient descent issues, which are critical for advancing GAN applications in deepfake detection.

In [9], the proposed methodology for detecting deepfakes leverages the average Laplacian value of video frames to assess authenticity. By analyzing these values, the method can quickly determine if a video is a deepfake; a high variability in the Laplacian value between the face frame and other frames indicates a low probability of authenticity, while a smaller difference suggests a higher likelihood of genuineness. However, it acknowledges limitations in universal applicability. This approach enables rapid

identification of deepfakes at a primary level, addressing the urgent need for efficient detection methods in the face of advancing deepfake technology.

[10] introduces a method for detecting deepfake segments at both frame and video levels, leveraging a Vision Transformer (ViT) for spatial features and a Timeseries Transformer (TsT) for temporal features. A benchmark dataset was created, revealing an average of 24.3% fake frames in videos with one fake segment and 41.1% in those with two segments. The method showed significant improvements in detection accuracy, thus providing a valuable tool for deepfake moderation. However, it faces limitations in detecting highly sophisticated deepfakes that may not align with the training patterns. The advantages include its dual-level detection capability and the effective use of a sliding window technique for enhanced classification accuracy.

METHODOLOGY

Deepfake detection architectures constitute a sophisticated suite of machine learning and deep learning frameworks, meticulously crafted to discern synthetic media, typically in the guise of convincingly altered videos or images, that simulate reality. In the context of deepfake detection, an architecture refers to the structured arrangement of models, layers, and algorithms that work together to extract unique features from manipulated content. The effectiveness of these architectures is intricately tied to their architectural design, spanning a spectrum from CNNs to hybridized models and transformer-based frameworks, each honing in on distinct features and patterns inherent to falsified content.

CNN based Architectures

XceptionNet Architecture

The XceptionNet architecture leverages depthwise separable convolutions to enhance computational efficiency while maintaining high accuracy. This approach divides traditional convolutions into depthwise and pointwise operations, significantly reducing parameters and computational cost. Inspired by Inception modules, Xception maximizes parallel filter processing, with 36 convolutional layers organized into 14 modules and linear residual connections to improve information flow and reduce training loss.

Xception's strong feature extraction capabilities make it highly effective for deepfake detection, identifying subtle

artifacts that signal image manipulation. The architecture's residual connections and use of batch normalization bolster its robustness, allowing for accurate performance on complex inputs, such as those found in deepfakes. Fine-tuning through transfer learning further enhances its application to facial manipulation detection, enabling the model to spot small inconsistencies in images and videos. The architecture's notable performance on large-scale datasets, including ImageNet, underscores its reliability for deepfake detection tasks.

ResNet Architecture

Residual Networks (ResNet) represent a pivotal advancement in deep learning, designed to address the challenges associated with training very deep neural networks. At the core of ResNet is residual learning, where instead of directly mapping inputs to outputs, the network learns to predict residuals- the differences between the input and the target output. This approach simplifies the learning process, allowing for the construction of networks with depths of up to 152 layers, significantly deeper than previous architectures like VGG, which had only 19 layers. This depth is made feasible by residual connections, which mitigate the vanishing gradient problem, leading to more efficient training and faster convergence, as demonstrated by superior performance on benchmarks like ImageNet and COCO.

The architecture employs 3×3 convolutional filters, batch normalization after each convolutional layer to stabilize learning, and global average pooling at the end to reduce feature map dimensions before classification. This innovative design led to a remarkable 3.57% error rate on the ImageNet test set, establishing ResNet as a foundational model in computer vision. The deep layers of ResNet excel at capturing the intricate patterns and features found in deepfakes, enabling effective differentiation between authentic & manipulated content.

EfficientNet Architecture

The EfficientNet architecture is a novel approach to scaling CNNs that emphasizes the importance of a well-optimized baseline network. The architecture begins with a mobile-size baseline model known as EfficientNet-B0, which is developed through a multi-objective neural architecture search that optimizes both accuracy and FLOPS (floating point operations per second). The results of this architecture are impressive, for instance, the EfficientNet-B7 model achieves a top-1 accuracy of 84.3% on the ImageNet

dataset, while being 8.4 times smaller and 6.1 times faster than competing architectures such as GPipe, highlighting its resource efficiency. Additionally, EfficientNets have shown strong performance on five out of eight widely used datasets while reducing parameters by up to 21 times compared to existing ConvNets.

The main building block of EfficientNet is the mobile inverted bottleneck convolution (MBConv), which is enhanced by squeeze-and-excitation optimization to improve feature representation. The architecture employs a compound scaling method that uniformly scales the depth, width, and resolution of the network, rather than scaling them arbitrarily. EfficientNet's ability to focus on key image features while maintaining a smaller model footprint makes it ideal for real-time detection tasks, especially in high-throughput environments like social media platforms. Additionally, its transfer learning capabilities allow pre-trained models to be fine-tuned for deepfake detection, ensuring that the network adapts to various datasets & manipulation techniques.

Inception-V3 Architecture

Inception-v3 is a sophisticated CNN architecture which employs modular Inception blocks that incorporate a variety of convolutional filter sizes, enabling the network to capture multi-scale features in an image. The architecture introduces factorized convolutions, replacing larger filters with smaller ones (e.g., two 3×3 convolutions instead of a 5×5), reducing the number of parameters and computational overhead without compromising performance. Additionally, dimensionality reduction techniques, such as pooling layers and 1×1 convolutions, effectively manage the computational load, while grid reduction techniques decrease spatial dimensions between Inception modules to maintain efficient information flow. Inception-v3's performance in large-scale image classification is underscored by its achievement in the ILSVRC 2012 challenge, with a top-1 error rate of 17.3% and a top-5 error rate of 3.5%.

In the realm of deepfake detection, Inception-v3 offers significant advantages due to its capacity to learn and extract complex features from high-dimensional image data. Inception-v3's multi-scale feature extraction capabilities allow it to discern subtle anomalies by capturing fine-grained details across varying resolutions. Its architectural efficiency also enables faster processing, a critical factor in real-time deepfake detection.

Table 1 Comparative Accuracy of CNN based Deepfake Detection Architectures

Model	DFDC	FF++	CelebDF
Inception-v3	85.6	90.5	89.4
Resnet-50	88.9	93.2	91.3
EfficientNet	94.1	98.7	96.3
XceptionNet	92.02	99.53	97.68

Transformer Based Architecture

Vision Transformer (ViT)

ViT is an innovative architecture that applies the transformer model. Departing from the traditional reliance on CNNs, ViT treats images as sequences of fixed-size patches, enabling it to process an image in a manner analogous to how transformers handle word sequences in text. Each image is divided into patches that are flattened and linearly embedded into a high-dimensional space. This representation allows the ViT to utilize self-attention mechanisms, which excel at capturing long-range dependencies and global context within the image. By doing so, ViT avoids the locality constraints of CNNs, offering a new approach to feature extraction and learning.

ViT's architecture also provides flexibility and adaptability in processing various types of visual data, as it is less dependent on image-specific inductive biases. Unlike CNNs, which rely on local receptive fields, ViT's global context awareness makes it particularly adept at identifying discrepancies that span across different regions of an image. This ability is crucial in detecting the intricate and often imperceptible alterations characteristic of deepfakes. However, ViTs require large amounts of labeled data for effective training, which can be a significant limitation in scenarios with limited data availability.

Convolutional Vision Transformer (CvT)

The Convolutional Vision Transformer (CvT) merges the strengths of CNN with ViT to elevate performance in image recognition, making it highly effective for deepfake detection. CvT introduces two key innovations: Convolutional Token Embedding, which replaces traditional patch-based inputs with overlapping convolutional patches, and Convolutional Projection, substituting the linear self-attention projection with depth-wise separable convolution. These modifications allow CvT to capture spatial details and contextual relationships

with improved precision, essential for detecting subtle artifacts in deepfake images.

CvT's hierarchical structure enables it to balance local and global feature extraction, equipping the model to identify minor inconsistencies characteristic of deepfakes. Benchmarked on datasets like ImageNet-1k and ImageNet-22k, CvT-21 achieved a top-1 accuracy of 82.5%, surpassing ResNet and previous Transformer models (ViT, DeiT) while maintaining fewer parameters and reduced computational overhead (FLOPs).

SWIN Transformer

The SWIN (Shifted Window) Transformer is a state-of-the-art architecture that addresses the limitations of CNNs and traditional transformers in vision tasks by segmenting images into non-overlapping windows. This design allows SWIN to balance detailed analysis with contextual understanding, making it effective for identifying subtle manipulations in deepfake images. Its hierarchical structure supports multi-scale processing, capturing both fine details and larger structures essential for detecting layered deepfake artifacts.

SWIN's window-based self-attention reduces computational complexity while maintaining accuracy, making it scalable for large datasets. Key features include region expansion and merging, which enable finer detail capture and effective global context observation, while bottleneck blocks improve learning efficiency in deeper layers. Validated on CelebDF and FF++ datasets, SWIN achieved high accuracy rates of 97.91% and 95.71%, respectively, demonstrating its ability to distinguish real from manipulated content. However, SWIN's performance can be sensitive to hyperparameter tuning, requiring careful optimization to achieve consistent results across diverse datasets, making it a powerful yet precision-dependent option for deepfake detection.

Class-Attention Image Transformer (CaiT)

CaiT is a refined Vision Transformer (ViT) model, tailored for image classification tasks that demand detailed feature extraction. Its enhancements include LayerScale within residual blocks to stabilize training in deep networks, enabling improved gradient flow and robustness for complex pattern detection. It's two-stage architecture introduces class-attention layers to isolate and refine class-relevant features, optimizing accuracy by prioritizing attributes essential for detecting forgeries. Advanced attention mechanisms, like talking-heads attention, further

improve its ability to capture complex correlations, critical for identifying subtle manipulations in deepfakes. Benchmark results on ImageNet show CaiT achieves 86.5% top-1 accuracy without extra datasets, balancing high performance with reduced computational demands.

Table 2 Comparative Accuracy of Transformer based Deepfake Detection Architectures

Model	DFDC	FF++	CelebDF
ViT	91.9	88.7	89.4
CiT	84.3	83.2	82.5
SWIN	89.6	86.3	87.2
CaiT	88.1	85.4	86.9

Hybrid Architectures

CNN – LSTM Architecture

The CNN-LSTM hybrid architecture leverages CNNs and Long Short-Term Memory (LSTM) networks to effectively address the challenges of deepfake detection by analyzing both spatial and temporal features in video data. This dual capability allows the architecture to detect subtle artifacts that may not be evident when frames are analyzed in isolation.

In this approach, CNNs are employed to process individual video frames and extract frame-level characteristics. These extracted features are then passed to the LSTM component, which models the temporal relationships across frames, identifying inconsistencies suggestive of deepfake content. This hybrid strategy enables the detection of optical flow irregularities and temporal distortions often present in manipulated videos. Performance evaluations have demonstrated promising accuracy rates, such as 66.26% on DFDC, 91.21% on FF++, and 79.49% on Celeb-DF datasets, even with reduced video samples of fewer than 100 frames.

CNN – Transformer Architecture

The CNN-Transformer architecture represents a cutting-edge approach that synergizes the strengths of CNNs and transformers. This architecture leverages CNNs to efficiently extract local features and patterns from images, constructing a context-rich vocabulary of image components. Once these local features are captured, transformers are utilized to model the global relationships and compositions between these elements, excelling at capturing long-range dependencies within the image.

This dual capability—local feature extraction coupled

with global context analysis—makes this architecture a powerful tool for distinguishing between authentic and synthetic content in deepfake detection systems. One notable implementation of the CNN-Transformer architecture employs EfficientNet B0 as the CNN backbone, where small image patches are processed to generate visual features representing crucial low-level information. These features are then passed into the transformer module, which applies self-attention mechanisms to analyze the global context of the image. This approach also simplifies the training process by allowing the transformer to build upon the solid foundation of visual features provided by the CNN. Empirical results further validate the effectiveness of the CNN-Transformer architecture in deepfake detection with an area under the curve (AUC) score of 0.951 and an F1 score of 88.0%, demonstrating its robustness in distinguishing real from manipulated content.

CNN – GAN Architecture

The CNN-GAN architecture combines the capabilities of CNNs and Generative Adversarial Networks (GANs) to enhance deepfake detection. CNNs serve as feature extractors, leveraging their layered structure to analyze spatial hierarchies and detect subtle visual discrepancies that may indicate manipulation. GANs, on the other hand, consist of two competing networks: a generator and a discriminator. The generator produces synthetic images, while the discriminator learns to differentiate these generated images from real ones.

The synergy between CNNs and GANs is utilized in two primary ways. First, GANs are used to augment the training dataset by generating synthetic images, broadening the diversity of the samples used for training. Second, The CNN consists of multiple layers, including convolutional and pooling layers, which extract essential features from images, followed by a fully connected layer that classifies the images as real or fake. The final classification layer often employs a sigmoid activation function, producing a probability score indicating the authenticity of the input, with a value closer to 1 denoting manipulated content.

Notably, the proposed model achieves an accuracy of 96.35% in distinguishing real from fake media. However, despite its efficacy, the training process is computationally intensive, posing challenges to real-time deployment.

Dual – Stream Architecture

The dual-stream architecture, introduced in [19] integrates

two complementary input modalities: RGB images and Spatial Rich Model (SRM) noise residuals. This design leverages the strengths of each modality to capture both visual and noise-based features crucial for detecting deepfakes. The RGB stream focuses on capturing the primary visual content and structural features, while the SRM stream emphasizes high-frequency noise residuals, which often contain subtle artifacts introduced during forgery.

To effectively fuse these inputs, the architecture employs a Cross-Modality Consistency Enhancement (CMCE) module, which aligns and integrates features from both modalities, preserving the unique information from each stream. This fusion is key to improving the model's ability to detect cross-modal inconsistencies and identify forgery artifacts that may not be apparent from visual analysis alone. Additionally, the model incorporates a Multi-scale Patch Feature Fusion (MPFF) module, which extracts features at multiple scales and aggregates them to retain spatial relationships between image patches. This multi-scale analysis improves the model's sensitivity to forgery cues across different image regions and resolutions. The dual-stream approach significantly outperforms single-stream architectures by effectively leveraging noise residuals and high-frequency details, achieving higher detection accuracy and improved resilience against unseen deepfake manipulations.

Table 3 Comparative Accuracy of Hybrid Deepfake Detection Architectures

Model	DFDC	FF++	CelebDF
CNN-LSTM	91.2	91.2	79.5
CNN-Transformer	87.2	89.4	85.3
CNN-GAN	83.3	85.1	82.4
Dual-Stream	71.3	99.8	84.6

CONCLUSIONS

This paper demonstrates a comparative analysis of CNN-based, transformer-based, and hybrid architectures for deepfake detection. CNN-based architectures excel in spatial feature extraction, effectively detecting pixel-level inconsistencies, making them well-fitted for real-world applications & demonstrated consistent spatial feature extraction abilities, achieving peak accuracy rates of up to 93.2% on FF++ with the ResNet-50 model and 97.68% with XceptionNet on CelebDF. However, their limited capacity for temporal modeling restricts their

effectiveness in video contexts. Transformer-based models address this limitation by capturing global dependencies through self-attention mechanisms, enabling the detection of sophisticated, context-rich manipulations. ViT achieved notable accuracy, reaching 91.9% on DFDC, underscoring their strength in capturing global dependencies within image contexts. While powerful, these models typically require extensive data and computational resources, making them more challenging to deploy in real-time settings.

Hybrid architectures combine the strengths of CNNs, transformers, and adversarial methods, enabling comprehensive analysis of both spatial and temporal information. These models are particularly effective for video-based detection. CNN-GANs leverage adversarial training to enhance robustness against sophisticated manipulations, attaining an average accuracy of 83.6% across datasets, while dual-stream architectures utilize parallel processing to examine RGB and optical flow information simultaneously, excelling in dynamic content with up to 99.8% on FF++. Collectively, these hybrid approaches demonstrate strong potential in detecting complex, multi-frame manipulations across diverse video contexts.

In conclusion, while each model category offers distinct advantages, future research should focus on improving hybrid models, multi-modal approaches, and scalability to counteract increasingly sophisticated deepfake generation techniques. This work underscores the need for continued innovation to enhance detection accuracy, efficiency, and robustness across diverse manipulation methods and forensic applications.

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Computationally Efficient Deep Learning Techniques for Monocular Depth Estimation: A Survey

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ABSTRACT

Monocular Depth Estimation is the techniques used for estimating depth of the 2D image. Deep Learning based methods are being extensively used in recent years for extracting depth information of the scene. Image depth information is an important feature of scene to perceive scene information in the field computer vision. This applies to various applications like 3D reconstruction of scenes, autonomous driving, robotic vision, indoor navigation of UAV etc. Traditionally methods like stereo vision, RGB-D, LIDAR or ultrasound devices were used to detect the obstacle distance from the camera frame, Monocular Depth Estimation (MDE) is one of the key approaches that can be used to perform this task. This approach uses a single camera image for computing the depth of the scene. For processing these images, the computer vision method uses Deep Neural Networks techniques. Implementation of Deep learning techniques requires a lot of computational resources. The goal of this paper is to present a summary of the most recent developments in deep learning-based MDE methods that require less computational requirements. For this goal, this paper mainly highlights the optimized networks with less computation. Major goal is to perform the depth estimation that can be implemented on edge computing devices, which are computationally less complex and accurate.

KEYWORDS : *Deep neural network, Edge computing, Monocular depth estimation.*

INTRODUCTION

Estimating depth information from photos of broad scenes is a critical difficulty in computer vision. This issue has been used in many applications, including 3D modeling, computer graphics, virtual reality, augmented reality, and autonomous driving. Robotic systems such as UAV, mobile robots rely significantly on it as a key component of their vision. Using active sensors, such as LiDAR and RGB-D cameras, can help achieve accurate depth perception.[1]. These gadgets, on the other hand, are bulky and need a lot of power, which prohibits them from being used on platforms with limited resources. The output of these sensors gives sparse output which requires further processing to extract the information. On the other hand, monocular depth estimation, or MDE, is not only affordable but also workable in compact form factors with good energy efficiency. A “depth map” image can be used to assess how far away an object is in the two-dimensional plane. Understanding the world around the camera plane is critical for a range of applications, including navigation

and mapping. This is useful for robots that need to investigate a scene or recognize an object’s features, as well as augmented reality systems that use compositional sensing. The robot receives information on an object’s 3D shape as it circles; it is not just the depth from a single vantage point, but the whole volume of the object in the scene [2].

Because of its wide range of applications, monocular depth estimation—the technique of estimating a scene’s three-dimensional structure from a single 2D image—has drawn a lot of interest in the computer vision and robotics domains.

Ranging from autonomous navigation to augmented reality, the Accurate depth information estimate is essential for robots to understand and engage with their physical surrounding [3]. Nevertheless, achieving real-time performance in depth estimation while concurrently maintaining computational efficiency and precision remains a formidable challenge.

Recently, there has been a renewed focus on the advancement of monocular depth estimate methods that carefully navigate the fine line between computational complexity and real-time capabilities [4]. This burgeoning interest is driven by the ever-increasing demand for applications that necessitate swift and accurate depth perception, including but not limited to autonomous vehicles [5], virtual reality experiences [6], and object detection systems [7].

Conventional depth estimation methods often rely on complex stereo camera setups or costly depth sensors, thereby restricting their scalability and accessibility in practical scenarios [8]. Calibration becomes important when using two camera setups. This setup requires cooperation from sonar sensors to properly navigate mobile robots [9]. In stark contrast, monocular depth estimation, hinging on the analysis of a single image, provides a more cost-effective and versatile solution [10]. Nonetheless, the pursuit of efficient monocular depth estimation techniques has faced significant challenges in achieving high-quality depth maps while conserving computational resources.

The overarching objective of this research paper is to confront this crucial issue by delving into novel approaches and algorithms aimed at enhancing the computational efficiency of monocular depth estimation, all the while preserving or even enhancing the precision of depth predictions. Our main goal is to advance methods that allow for real-time depth estimation on devices with limited resources, such as edge computing devices, without sacrificing output quality.

BACKGROUND OF MONOCULAR DEPTH ESTIMATION

Problem Definition

The following is a typical problem formulation for monocular depth estimation: One way to conceptualize monocular depth estimation from a single picture is as a pixel-level process, presuming the presence of a sizable training set of RGB-depth pair images. Finding the depth for each pixel which is represented as depth map. This map will represent the different shades to represent the various distance of objects from the focal length of camera.

More precisely, the following is how you approach the challenge of predicting a depth map from a single RGB picture. Let $\mathcal{I}$ be the single RGB scene image with size $w \times h$ and D is depth map of $\mathcal{I}$ of same image. The task of MDE is to learn a non-linear mapping $\Phi: \mathcal{I} \rightarrow D$.

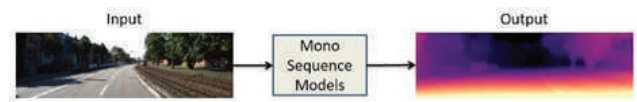


Fig. 1 Input output structure of Monocular Depth Estimation [2]

Performance Evaluation metrics

To assess performance of depth estimation method a recognized evaluation method was suggested by Eigen et al. [11]. This method contains five evaluation metrics which includes “absolute relative difference (Abs-Rel), square relative error (Sq-Rel), linear root mean square error (RMSE), logarithm root mean square error (RMSE-log)”.

Given a predicted depth map D^P and the actual depth map D^A , let D_i^P and D_i^A represent the predicted and actual depth values at the pixel i , respectively, and N represent the total number of pixels for which depth values are available. The following is a set of assessment measures that have been often utilized in previous research to compare the predicted depth map and truth map quantitatively:

Absolute Relative Difference (Abs Rel)

$$Abs\ Rel = \frac{1}{N} \sum_N \frac{|D_i^A - D_i^P|}{D_i^P} \quad (1)$$

Squared Relative Difference (Sq Rel)

$$Sq\ Rel = \frac{1}{N} \sum_N \frac{|D_i^A - D_i^P|^2}{D_i^P} \quad (2)$$

linear Root Mean Square Error (RMSE):

$$RMSE = \sqrt{\frac{1}{N} \sum_N |D_i^A - D_i^P|^2} \quad (3)$$

Logarithm Root Mean Square Error (RMSE log)

$$RMSE = \sqrt{\frac{1}{N} \sum_N |\log D_i^A - \log D_i^P|^2} \quad (4)$$

MONOCULAR DEPTH ESTIMATION STRATEGIES

This section describes the various deep Learning methods incorporated for Monocular depth estimation. Specifically, it mentions about computationally efficient techniques and an outline of the evolution.

Poggi et al. [12] introduced unsupervised model. This

framework proposes a very low resource need technique for precise and unsupervised monocular depth estimation, enabling this operation to be performed even on CPUs with minimal power consumption. This work proposes compact CNN to cut down on the enormous number of parameters and memory utilized in depth estimation techniques. For real time application memory footprint is reduced to less than 150MB to work on embedded devices. Here author proposed method for large reduction in parameters count along with quick computation in optical flow. The network is named with PyD-Net. This network is comprised on three stages Pyramidal feature extractor, Depth decoder and upsampling and calculating training loss. Global references can be included at lower resolution thanks to the coarse to fine process. Further refining the details at higher resolutions producing reduced amount of parameters and memory footprints.

PyD-Net is a lightweight deep learning algorithm that uses decoding and upsampling stages to process extracted features. It uses a sigmoid operator and deconvolution to double spatial resolution. The feature is then concatenated with upsampling and repeated to the highest resolution level. This method reduces memory requirements and runtime, and calculates training loss at each resolution. The algorithm is tested on the KITTI dataset and compared to state-of-the-art Unsupervised Networks for monocular depth estimation. The method is suitable for embedded systems and achieves good accuracy due to its smaller number of parameters.

The method proposed by Wofk D. [13] uses fully convolutional encoder-decoder architecture is shown in Figure 2. This work describes a deep estimation network using MobileNet as an encoder, which uses depthwise decomposition to extract high-level, low resolution information from an input image. This process reduces complexity by factorizing an $m \times m \times n$ convolutional layer into n $m \times m$ layers and a 1×1 pointwise layer. The extracted features are then passed through a decoder, which undergoes gradual upsampling and skip connections to reduce the decoding layer's processed feature map channel count. The network is compiled using hardware-based compilation, using the TVM compiler stack for deployment on embedded boards like the Jetson TX2. The authors use the unique Algorithm NetAdapt to develop a real-time depth estimation network using low-latency designs, continuously and automatically finding and eliminating superfluous channels until the desired level of accuracy and complexity is reached. This efficient network

can be applied to high frame rate image sequences with low latency without disrupting existing runtime. The study suggests similar strategies for other dense prediction problems, such as picture segmentation, to achieve real time performance using deep-learning-based methods.

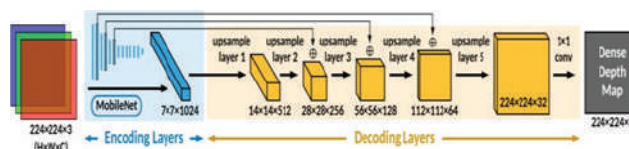


Fig. 2 Proposed Network Architecture of MOBILENET [13]

In this work [14] authors propose a compact self-organizing network for MDE using which used single camera, this method uses a collaborative design technique between humans and machines. The approach involves two phases: machine-driven exploration and principled network design prototyping. The first phase involves the encoder-decoder architecture, which extracts low to mid-level features and reconstructs a rich depth map.

This method has direct connections between encoder and decoder layers, strengthening feature propagation and reducing vanishing gradient issues. Skip connections in the decoder architecture enhance the level of detail in the decoder output. The second phase involves machine-driven design exploration, incorporating data, initial network design prototype, and human constraints. The designs of macroarchitecture and microarchitecture for depth estimation on edge computing devices are determined through machine-controlled design exploration and generative synthesis. This method demonstrates DepthNet Nano's fast inference speeds and energy efficiency on platforms like Jetson AGX Xavier module.

This work [15] proposes a new network architecture of unsupervised learning techniques for MDE in embedded systems /edge devices. The architecture consists of a DepthNet and two PoseNets with shared weights. The inference stage uses DepthNet, a recurrent module that constructs an encoder with identical input and output channel sizes. The feature size is halved after each recurrent pass, achieving effects comparable to deep Convolutional Neural Networks but with significantly lighter parameters. A unique efficient block is introduced for upsampling, reducing feature parameters and floating-point operations. The unsupervised method is implemented using two stages: training and inference. In the training

phase, MiniNet is fed three consecutive video frames, with the middle frame as the target frame and the other two as source frames. The model size is 0.871 Megabytes, with a 32.2% improvement in AbsRel metric and 158 times lesser parameters.

[16] The MobileXNet method uses shallow encoder-decoder style subnetworks with standard convolutional layers. The first subnetwork samples a monocular image four times, producing feature maps F1 and F2. This is then passed through two upsampling stages to produce feature maps F2 and F3. Skip connections are added to collect fine-grained image information, increasing running speed. Depthwise convolution is used in the first subnetwork to reduce computation by 8 to 9 times, improving computational speed. The depth estimator performs better because the network's wider receptive field gathers more context data. The decoder receives captured context information of images at multiple scales and has a bridge module between encoder and decoder blocks. The upsample layer, which includes interpolation, convolution, up-projection, unpooling, and transpose convolution, is the central component. Performance is better with up-projection, but it increases network parameters. The bridge module has three dilated convolutional layers and increases the intermediate feature maps' spatial resolution via bilinear interpolation. The method is tested on desktop PCs with graphics and datasets like NYU depth V2, KITTI, and Make 3D. The author claims that MobileXNet runs faster on a single GPU, crucial in real-time autonomous driving and robotic applications.

In this paper [17], Feng Wei et al. developed an unsupervised approach for monocular depth estimation using deep separable convolution. This method enhances network architecture, for reducing training parameters, and improves computational speed. The method relies on optimisation by lowering network parameters and floating point operation while maintaining output depth information. The network is made up of encoders and decoders that work together to create a precise depth map and segment the input target picture semantically. The output is more precise because the decoder integrates features from several levels to increase feature accuracy and details. The decoder uses skip-connections to restore details, while the encoder extracts depth features from the input image. The method is based on the traditional residual network Resnet50 and introduces depth separable convolution. After applying the method on the KITTI dataset, the network parameters were reduced by 2.67

times, resulting in better image quality. The method works well for detecting small objects but requires improvement in reconstructed boundary of objects.

M. Xiong [18] et al. proposes improvement in encoder-decoder architecture called as LD-Net which is self-supervised framework. LD-Net is a network that uses downsampling blocks and an Atrous Spatial Pyramid Pooling (ASPP) module to estimate depth. It uses predictions of multiscale i.e. six independent downsampling units to decrease computational complexity. The feature map is predicted from downsampling unit from encoder block.

In decoder unit this method performs upsampling produced by including a sub-pixel convolutional layer. This makes super resolution operation because of which information is abundant after this layer. Hence the method is beneficial in depth estimation.

In [19], a novel compact encoder-decoder architecture is proposed, integrating an edge guidance branch. In order to extract edge attention features, this branch uses gradients from the input picture and multi-scale feature maps derived from the backbone. To effectively amalgamate edge attention features and context information the authors introduce a module known as Transformer-based Feature Aggregation (TRFA). Utilizing a cross-attention technique, this module captures long-range relationships between edge attention characteristics and context information. The methodology is organized into four components: a multi-scale feature extractor, the edge guidance branch, the feature aggregation module, and the decoder.

In Multiscale feature extractor which consist of MobileNetV2 [19] and an extension module. The MobileNetV2 backbone produces features of 1/16 size from input images. The extension module enhances the representation of features using six dilated Inverted Residual Blocks (IRBs) and a single residual block with different dilation rates. The Edge guidance branch stage uses channel attention-based feature fusion modules (CAFF) to produce edge images and high-resolution feature maps. The transformer-based feature aggregation module (TRFA) creates high-resolution depth maps by combining context-rich features from the Multi Scale Feature Extractor with edge attention features from the EGB. This module is deployed on Nvidia GTX 1080 GPU (2580 CUDA cores and 8GB memory). Also, after comparing the EGDNet with some existing method, number of parameters found to be lowest.

Duong H. et al. [20]. proposed a network called URNet, which combines UNet, an encoder decoder structure, and residual learning mechanisms. The method was applied to the KITTI dataset and found to have higher precision and lower error rate. The methodology involves upgrading UNet-based nodes with residual blocks, using Atrous Spatial Pyramid Pooling (ASPP) as a transfer node. The encoder and decoder blocks are connected using two connections, unlike conventional UNets. Attention blocks extract and focus additional features, enhancing performance. The network consists of three small blocks, each receiving input from the encoder unit and decoder. The ASPP block captures transfer node characteristics and network endpoint rates. The method also incorporates an attention block and ASPP, which are widely used in segmentation. A variation called DenseASPP reduces computational complexity and enhances precision, making it potential for autonomous driving systems.

In [21] Author introduced the technique called AnyNet which specifically designed for mobile devices. This method is experimented on Nvidia Jetson TX2 GPU Module for the frame rates of 10 to 35 FPS. Author targeted the disparity prediction as the first stage. In proposed AnyNet structure four stages network is proposed to extract the disparity.

The AnyNet receives the feature maps from UNet Feature Extractor with different scale from 1/4 to 1/16. Three stages are disparity network were generating disparity map. First stage processes only lowest scale feature (1/16). The output of first stage is passed through second stage to increase the resolution with feature scaling of 1/8. Further it is computes for 1/4 scale in stage 3. Last stage uses SPNet to refine disparity map obtained from Stage 3. This proposed method is experimented on KITTI-2012 and KITTI-2015 datasets. This work claims to be first algorithm for estimating anytime depth from stereo images.

The work done by Huilan Luo et al. [22] focused on decoder part of MDE Network. The author proposed "Pixel shuffle upsampling decoder" known as PSDNet. This network is adopted from UNet Architecture. The method is proposed to reduce the computing parameters, reducing object distortions and for clearer contours. This method is using spatial pyramid connection module named as "EESP" for skip connections. This connection module passes features at different level to PSD Module. The PSD module is better at improving resolution of feature maps. Proposed method also does not add extra parameters to computation.

This method is experimented on NYU depth V2 dataset. The proposed method achieves greater accuracy in estimating contours of objects, less distortion in objects and less missing objects.

Liu S. et al. [23] worked on MDE method specifically on IoT devices. A minimal encoder and decoder are included in MDE. The encoder pulls useful characteristics and inherits the benefits of existing lightweight networks. Here Using depth wise separable convolutions, the decoder quickly retrieves depth information.

Following table shows comprehensive information and comparison of all discussed methods showing the hardware platform used for implementation and runtime of respective methods.

Table 1 Runtime and hardware platform used for different methods of monocular depth estimation

Method	Hardware Platform	Runtime (ms)
Poggi [12]	Titan X	20
	Intel i7-6700K	120
	Raspberry Pi3	1720
Wofk [13]	Jetson TX2- GPU	5.6
	Jetson TX2 – CPU	37
Wang [14]	Jetson AGX Xavier	71
Liu [15]	Nvidia GTX 1080 Ti GPU	9.16
	Intel E5-1630 CPU	27
Dong [16]	Nvidia GTX 1080 GPU	7.9
Wei [17]	NVIDIA GeForce RTX 2080	1200
Xiong [18]	Nvidia GTX 1080 Ti GPU	7.32
Dong [19]	Nvidia RTX 3090	10.4
Wang [20]	Nvidia Jetson TX2 GPU	97.3
Luo [21]	NVIDIA GeForce RTX 2080Ti	NA
Liu [22]	Nvidia Jetson TX2 GPU	11
	Nvidia Jetson Nano	28

FUTURE SCOPE

Supervised, unsupervised deep learning techniques were majorly used for MDE. But supervised training requires lot of data to train the system. and the performance can't be predicted on unknown scenes. Unsupervised techniques affected by accuracy of generating depth map. To overcome this Generative Adversarial Network can be used to train the MDE model to improve accuracy and processing this data locally. Also, self-supervised method can be explored to bridge gap between supervised and unsupervised techniques. Further these techniques can also be explored in the field of underwater scenes and endoscopy.

CONCLUSION

Monocular depth estimation requires deep learning techniques, but these techniques undergo different layers of network. Due to which number of parameters required for computation are huge. The techniques summarized in the paper are focused on reducing the number of parameters which incur fast computation. Also, the number of layers to process the input images can be modified and inclusion of skip connections make the system efficient. Most of the network used encoder decoder architecture to reduce the parameters encode parameters can be tuned at input side and by tuning decoder output stages can be tuned. With this approach the computation for estimating depth can be done locally on hardware to make the system real time. In recent days, CNN based architecture are used to improve the accuracy, implementing them on the Edge devices are not possible due to complexity of architectures. Also, computational requirements are also huge to be accommodated. Researchers are continuously upgrading the Networks, but generic network architecture can be next scope of the research in this field of depth estimation.

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DDoS Attacks Detection Using Machine Learning and Deep Learning Techniques using Hybrid System

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ABSTRACT

Distributed Denial of Service (DDoS) attacks have emerged as a significant threat to the stability and security of modern networks. These attacks leverage multiple compromised systems to overwhelm a target, rendering it inaccessible. The growing sophistication of DDoS attacks necessitates the development of advanced detection mechanisms. Machine Learning (ML) and Deep Learning (DL) techniques have proven to be highly effective in identifying and mitigating such threats. This paper provides a comprehensive review of existing ML and DL approaches for DDoS attack detection, analyzing their methodologies, performance, and limitations. A detailed literature survey is also presented, highlighting key contributions from researchers in this domain.

KEYWORDS : *Distributed Denial of Service (DDoS), Machine learning (ML Deep learning (DL), Attack detection, Detection mechanisms.*

INTRODUCTION

The DDoS attacks are among the most prevalent cyber threats today, disrupting services and causing significant financial and reputational damage. Traditional signature-based and rule-based detection mechanisms often fail to address the dynamic nature of these attacks. Consequently, ML and DL methods have gained prominence due to their ability to adapt and learn from evolving attack patterns. This review explores state-of-the-art ML and DL techniques for DDoS detection, emphasizing their comparative advantages and challenges[1]. The advent of the internet and widespread adoption of networked systems have transformed how businesses and individuals operate. However, these advancements have also introduced significant cybersecurity challenges. One of the most persistent and disruptive threats in this domain is the Distributed Denial of Service (DDoS)

attack. DDoS attacks aim to overwhelm a target system, server, or network with a flood of malicious[2]. Traffic, rendering it inaccessible to legitimate users. These attacks exploit the scale and anonymity offered by botnets, making them increasingly sophisticated and difficult to detect. The traditional methods for DDoS detection, such as signature-based and rule-based systems, have shown limited effectiveness in handling the evolving nature of these attacks.

Signature-based approaches rely on predefined patterns of known attacks, making them ineffective against zero-day threats or novel attack patterns. Similarly, rule-based techniques often struggle with scalability and require constant manual updates to remain effective[3]. As DDoS attacks grow in complexity, traditional approaches fail to meet the demands for real-time detection, adaptability, and scalability. Machine Learning (ML) and Deep Learning

(DL) techniques have emerged as promising alternatives for DDoS detection. Unlike traditional methods, these techniques have the ability to analyze large volumes of network traffic data, learn patterns, and adapt to new attack behaviors. ML methods such as Random Forest, Support Vector Machines (SVM), and K-Nearest Neighbors (KNN) offer interpretable and effective solutions, while DL architectures like Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) excel in identifying complex patterns and temporal dependencies in data[4]. Moreover, advanced models like Autoencoders and Generative Adversarial Networks (GANs) further enhance detection capabilities by addressing challenges such as class imbalance and the need for synthetic data generation. This paper explores the application of ML and DL techniques in DDoS attack detection[5]. It provides a detailed analysis and comparison of various approaches, focusing on their methodologies, performance, and limitations. The study also highlights the scalable, efficient, and real-time detection mechanisms. By leveraging the strengths of ML and DL, this research aims to contribute to the development of robust and adaptive solutions for mitigating the impact of DDoS attacks.

In today's interconnected world, cyber threats have become more sophisticated and persistent, posing significant risks to individuals, organizations, and critical infrastructure. Among these threats, Distributed Denial of Service (DDoS) attacks remain one of the most prevalent and challenging to mitigate. By overwhelming a target server, network, or application with massive amounts of traffic, DDoS attacks disrupt normal operations, rendering services unavailable to legitimate users. This not only leads to financial losses but also damages the reputation and trustworthiness of the targeted entity.

The increasing frequency and diversity of DDoS attacks, ranging from volumetric to low-rate attacks, demand robust detection mechanisms. Traditional methods, such as signature-based and rule-based detection systems, rely on predefined patterns or static rules to identify malicious traffic. While effective against known attack vectors, these methods are limited in their ability to adapt to the dynamic and evolving nature of modern DDoS attacks. Attackers constantly innovate, using botnets, encrypted traffic, and new evasion techniques to bypass traditional detection systems.

Machine Learning (ML) and Deep Learning (DL) have emerged as transformative technologies in the fight against DDoS attacks. By leveraging data-driven approaches,

these techniques can identify patterns and anomalies in network traffic, even for previously unseen attack types. ML algorithms, such as Random Forest, Support Vector Machines (SVM), and K-Nearest Neighbors (KNN), provide interpretable and computationally efficient models for DDoS detection. These methods excel in feature selection, classification, and anomaly detection, making them suitable for identifying attack patterns in smaller datasets or less complex scenarios.

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On the other hand, DL techniques, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Autoencoders, and Generative Adversarial Networks (GANs), offer unparalleled capabilities for processing large-scale and high-dimensional data. CNNs are particularly effective in extracting spatial features, while RNNs capture temporal dependencies in time-series network traffic. Autoencoders provide unsupervised anomaly detection by learning latent representations of normal traffic, and GANs enhance detection systems by generating synthetic attack data to improve model robustness.

The choice between ML and DL techniques often depends on the specific requirements of the application. While ML methods are computationally less demanding and easier to interpret, DL approaches are better suited for complex, high-volume datasets but require significant computational resources and expertise. Despite their strengths, both approaches face challenges in scalability, real-time performance, and generalization across diverse attack scenarios.

This paper provides a detailed exploration of ML and DL techniques for DDoS detection, offering insights into their methodologies, performance, and limitations. By analyzing state-of-the-art methods and comparing their effectiveness, this study aims to identify best practices and highlight areas for future research. With the rise of increasingly sophisticated cyberattacks, advancing the capabilities of DDoS detection systems through ML and DL is crucial for ensuring the security and reliability of modern networks.

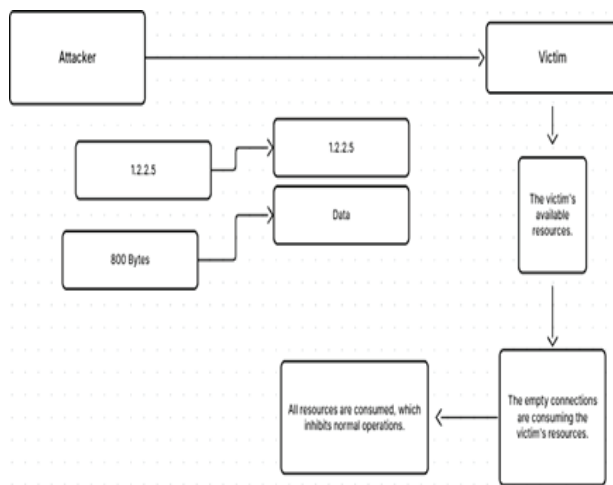


Fig. 1. Attack System

LITERATURE REVIEW

The increasing dependence on digital networks has enhanced connectivity but also raised the risk of cyber attacks. Information Forensics and Security, 2020 . This study employs Random Forest for feature selection and classification in detecting volumetric DDoS attacks. The proposed model achieved a detection accuracy of 94% on the CICDDoS2019 dataset[1]. The authors used SVM for identifying low-rate DDoS attacks. The results indicated an 89% precision rate but suffered from high computational overhead during training [2].

This research demonstrated the use of KNN in classifying attack traffic in SDN environments, achieving 92% accuracy but limited scalability with large datasets [3]. The authors proposed a CNN-based model for detecting DDoS attacks in IoT networks. The model achieved an F1 score of 96% but required high computational resources [4]. This paper explored the use of RNNs to detect time-series patterns in network traffic, effectively identifying both high-rate and low-rate DDoS attacks with 95% accuracy. Autoencoders were used to detect anomalies in network traffic indicative of DDoS attacks. The unsupervised approach achieved 93% detection accuracy with minimal labeled data [5]

This study introduced a GAN-based model for generating synthetic attack data to train robust DDoS detection systems. The model improved detection rates by 3-5% compared to traditional DL techniques [6]. Gradient Boosting was employed to handle feature-rich datasets, achieving improved precision but at the cost of increased training time[7]. A CNN model was proposed for detecting DDoS attacks in IoT environments. It achieved an F1 score of 96% but required high computational resources[8]. RNNs were employed to analyze temporal patterns in network traffic. The model identified both volumetric and low-rate attacks with 95% accuracy [9]. Autoencoders were used for anomaly detection without labeled data, achieving 93% detection accuracy [10]. GANs were applied to generate synthetic attack data for training robust detection models [11]. The method improved accuracy by 3- 5%. Ensemble methods, combining multiple classifiers, improved robustness and accuracy in detecting both known and unknown DDoS patterns. Reinforcement learning-based models were used to adaptively defend against evolving DDoS threats. Bidirectional LSTMs captured long-term dependencies in traffic sequences, enhancing detection rates for advanced DDoS attacks. Transfer

learning enabled the model to generalize across different network domains, improving cross-domain detection rates. Federated learning allowed collaborative detection while maintaining user data privacy [12]. Addressed data imbalance issues in training datasets, proposing methods to improve model fairness [15]. Focused on developing real-time detection systems to meet the performance needs of modern networks. Proposed lightweight models for IoT devices with constrained computational resources [18]. Explored solutions to enhance scalability for processing high-volume network traffic. Addressed the challenge of making ML and DL models interpretable and transparent for practical deployment [19]. This study utilizes Random Forest for selecting critical features and classifying network traffic Distributed Denial of Service (DDoS) attacks pose a persistent threat to modern networks, disrupting services and causing substantial economic and reputational damage. As traditional signature-based methods falter in detecting evolving threats, researchers have focused on Machine Learning (ML) and Deep Learning (DL) for their adaptability and scalability. This review delves into various approaches, highlighting their methodologies, strengths, limitations, and real-world applicability [20]. Applied on the CICDDoS2019 dataset, the model achieved a detection accuracy of 94% [21]. Decision Trees were used for real-time anomaly detection with a focus on low computational overhead [22]. DL techniques offer unparalleled accuracy and adaptability, making them suitable for dynamic and heterogeneous network environments. However, their computational requirements and limited interpretability pose challenges for deployment in resource-constrained or regulated environments. The paper proposed a CNN model for IoT network security, achieving an F1 score of 96%, albeit with high computational requirements [23].

RNNs were employed to capture time-series patterns in network traffic, identifying both volumetric and low-rate attacks with a 95% accuracy rate [24].

The research introduced auto encoders for detecting anomalies without labeled data, achieving 93% detection accuracy. GANs were used to generate synthetic attack data, improving robustness and detection accuracy by 3-5% compared to traditional DL methods [25].

RESEARCH METHODOLOGY

Data Collection Dataset Selection: Select an appropriate dataset containing labeled network traffic data.

Private Data: If available, use real network traffic data

from a specific organization. **Data Preprocessing:**

Handle missing values, remove duplicates, and resolve inconsistencies.

Feature Extraction: Extract relevant features from raw data: Time-based: time stamps, interarrival times, packet rates. Flow-based: source/destination IP addresses, port numbers, protocol types. Statistics mean, standard deviation, variance of traffic parameters.

Model Selection and Training Supervised Learning:

Support Vector Machines (SVMs): Effective for High-Dimensional Data. **Random Forest:** Ensemble Method for Improved Accuracy and Robustness. **K-Nearest Neighbors (KNN):** Simple and intuitive, but can be computationally expensive. **Naïve Bayes:** effective for large datasets, but assumes independence of features. **Unsupervised Learning (for anomaly detection):** K-Means Clustering Identifies clusters in data and reports anomalies.

One-class SVM: learns normal traffic patterns and detects anomalies. **Deep Learning Models** Convolutional Neural Networks (CNN) great for image-like data (e.g., network traffic patterns visualized as images). Recurrent Neural Networks (RNNs), especially Long Short-Term Memory (LSTM) capturing Temporal Dependencies in Sequential Data (e.g., network traffic time series). **Rating Accuracy:** Overall accuracy of predictions. **Accuracy:** the ratio of true positives to all expected positives. **Recall:** the ratio of true positives to all true positives. **F1 score:** the harmonic mean of precision and recall. **True positive rate (TPR), false positive rate (FPR), receiver operating characteristic (ROC) curve, area under the curve (AUC).** Performance comparison the performance of different machine learning and deep learning models using selected evaluation metrics. **Statistical significance tests:** Determine whether performance differences between models are statistically significant.

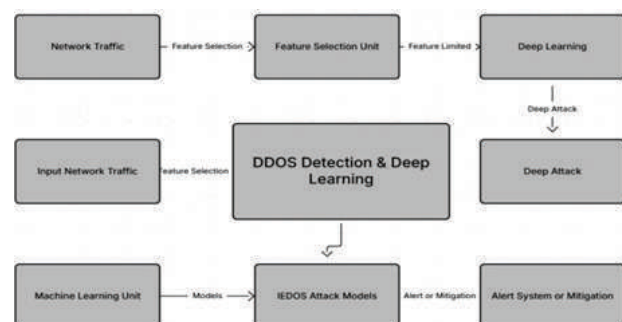


Fig 2. System Diagram

PROPOSED SYSTEM

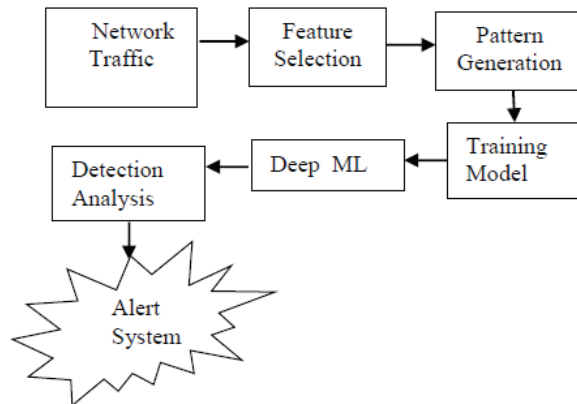


Fig 3. System Flow

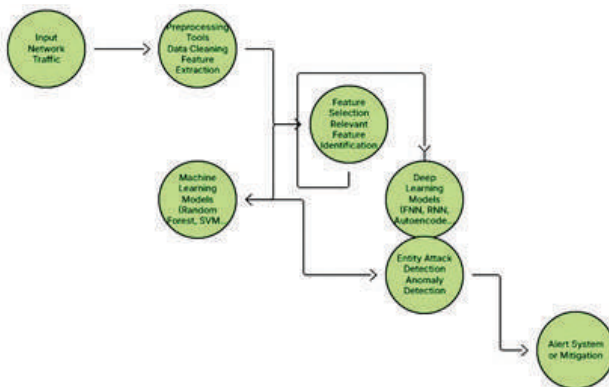


Fig.4. Process Flow

The models were implemented using popular machine learning and deep learning frameworks, including:

- Scikit-learn: For traditional ML algorithms.
- TensorFlow and PyTorch: For implementing DL models.

Experiments were conducted on a high-performance computing cluster to ensure scalability and handle large volumes of data. Hyper parameter tuning was performed using grid search and random search techniques to optimize model performance.

CONCLUSIONS

The incorporation of Artificial Intelligence (AI) into Intrusion Detection Systems (IDS) has demonstrated great potential in overcoming the challenges faced by traditional IDS approaches. AI techniques, especially machine learning and deep learning, enhance the ability of IDS to identify advanced and previously unknown cyber threats,

such as zero-day exploits and advanced persistent threats (APTs). AI-powered IDS models excel in improving detection accuracy, minimizing false positives, and dynamically adapting to evolving attack methods, making them significantly more effective than traditional systems.

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Automated Email Response and Word Frequency Analyzer

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ABSTRACT

Email communication is a key part of personal and professional interactions in the digital age. But coping with a high volume of emails in an effective way is still a challenge. So, here we present an Automated Email Response And Word Frequency Analyzer that can automate the email generation process through NLP and ML techniques, as well as analyze the frequent words. The system proposed extracts emails using Gmail API, the extracted text undergoes preprocessing techniques like tokenization, stop-word removal, etc. to classified the incoming emails on sentiment and intent. The system automatically generates appropriate responses by classifying the issue and decreasing the manual force. Data training ensures the maximum quality of the content produced, tailored to the style and voice of an organization up to such a period, and helps maintain ethical and compliance standards. This system context can be extremely useful in many domains. In automating customer support, it allows businesses to produce fast and relevant replies to frequently asked customer questions, enhancing the efficiency of responses and lessening the requirement for manual mediation. The system has many functions that help, especially in corporate work environments such as going through large piles of writing and only notifying the sender if there is a valuable subject (so they do not lose any mail), and trying to find as much information on your document as possible. It acts like a personal assistant in a way, reading over a person's emails to assess sentiment and intention before spitting out subjective responses tailored to user-defined parameters. This study demonstrates that this method greatly increases email managing efficiency and enhances email response accuracy with appealing linguistics features. Email automation is one of the fields where AI can facilitate work in order to relieve business or personal emails in bulk.

KEYWORDS : *Automated email response, Sentiment analysis, Natural language processing, Word frequency analysis, Machine learning, Email automation, AI communication.*

INTRODUCTION

Email has become an essential means of communication in this age of technology, both in the professional arena as well as in our personal lives. The entirety of organizations, businesses and individuals rely on emails for communication, customer service, and general information. But dealing with high volume emails manually can become extremely time-consuming and inefficient. Failure to respond to emails can cause missed opportunities, and decreased productivity, and customer dissatisfaction. Automation in email management is

gaining traction for solving such problems, with AI and NLP in the spotlight as potential game-changers. The Automated Email Response and Word Frequency Analyzer is a system developed to help users increase the efficiency of their communication management when dealing with emails, through automated responses and commonly used words analysis.

This system proposed as part of the research structured using the integration of NLP and ML techniques to process incoming emails classify sentiment and intent classify them and generate responses to them. Using the Gmail

API, pulls emails out, preprocesses the text, makes a prediction on sentiment and intent, and finally classifies it. Then, using predefined rules and AI-driven models, it creates automated responses that are contextually relevant. The various lemmatization forms of a word are also being queried for the same reason as the word frequency analysis module. This information enables businesses and organizations to improve their email strategies, maximizing customer engagement and response.

This research that actually points toward AI-powered email automation in less human effort in emailing answers, better accuracy, sorting, and efficiencies in managing emails. The system is especially appropriate to customer support services, corporate communications, academic institutions and even people who manage a lot of emails every day.

RELATED WORK

AI-powered Automation in Email Management AI and NLP have come a long way in automating the email response process. An example of such advancements being made is Google's Smart Reply system, which composes short, context-sensitive emails. Smart Reply is designed using large-scale deep learning models based on a large scale with the help of available data, enabling it to suggest appropriate replies for effective communication and increased efficiency from the user perspective. This well-tread approach has been widely embraced, capable of closing the loop on a large percentage of mobile email replies.

The field of academic communication has seen research on automating standard responses to commonly asked questions. Another relevant line of research is sentiment analysis for automatic replies to emails in teacher-student interactions which shows the possibility of classifying emails by sentiment to provide appropriate responses. The goal is to free teachers from sending the same email over and over to save time that can be used for teaching.

METHODOLOGY

Word Frequency Analyzer and Automated Email Response is an organized and systematic approach utilized to manage emails effectively, generate automated responses, and detect language trends to make the right decisions. It relies on the combination of Natural Language Processing (NLP), Machine Learning (ML), and Data Analytics to classify emails accurately, generate smart responses, and derive linguistic trends remarkably. Every step in this approach is crucial to make the process of email

management more efficient and improve the effectiveness and accuracy of communication.

Email Extraction

The initial step involves logging in securely and retrieving emails from the user's inbox. The system signs in to an email account through an APP password and Data API, which provides authentication without disclosing sensitive credentials. It employs the IMAP to search the inbox for unread email, retrieve needed metadata (information about the sender, subject line, timestamp), and retrieve the content of email. Filtering of emails based on pre-defined requirements, such as unread emails or certain keywords, ensures that relevant emails are acted upon.

Preprocessing Email Content Using NLP

After the extraction process is over, the emails are then passed through a detailed preprocessing phase that cleans and organizes the data, which is necessary for correct analysis. During this preprocessing phase, the system carries out text cleaning operations based on the Natural Language Toolkit (NLTK), which includes several necessary procedures such as the removal of special characters, stop word removal, and the removal of any unwanted whitespace. After this initial cleanup, tokenization is carried out to split the email content into words or tokens, which is a necessary step. Lemmatization is then carried out, which is used to bring words down to their base or root form, as can be observed in the example where "running" is brought down to "run." These laboriously carried out steps are necessary because they normalize the text, ultimately improving the accuracy and reliability of the ensuing analytical processes that follow.

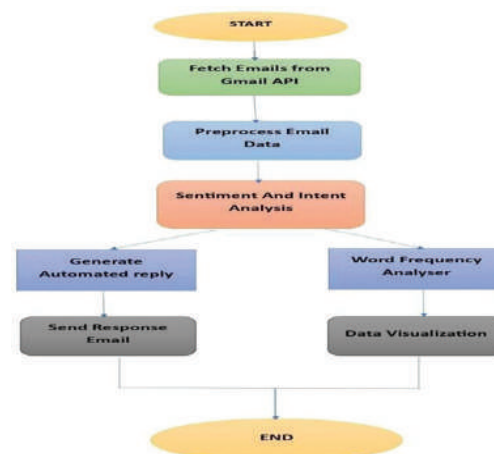


Fig 1 Proposed Methodology

In addition, the system is also taught to properly identify and eliminate boilerplate text, which includes signatures, disclaimers, and automated footer messages, all of which add absolutely nothing to the sentiment or intent. Additionally, advanced named entity recognition (NER) is utilized with great care to precisely recognize important names, organizations, or locations that can play a considerable role in the overall sense of the email. After this is done, the cleaned and standardized data is then securely stored in a temporary database so that it can be properly processed in the following stages of analysis.

Sentiment Analysis and Intent Classification

In order to identify the tone and purpose of the email in an efficient way, the system utilizes sentiment analysis with the assistance of NLTK's VADER, which is an acronym that stands for Valence Aware Dictionary and sentiment Reasoner. This specific method operates on the basis of categorizing emails into three different categories: positive, negative, or neutral, on the basis of the sentiment analysis in accordance with the computation of sentiment scores from the email content. Apart from this, an intent classification procedure is performed in the system in an automatic way, where a pre-defined set of default response mappings is used to map unique words that occur in the subject line of the email to corresponding responses that have already been set. For instance, if the subject line contains the word "complaint," the system is set in such a manner that it automatically selects and gives an appropriate response from the designated complaint response function. This rule-based mapping process not only simplifies the process but also ensures that the generated replies are accurate and contextually relevant with no manual intervention whatsoever.

The VADER (Valence Aware Dictionary and sentiment Reasoner) model assigns scores to words and calculates the overall sentiment score of an email.

Automated Response Generation

Based on the classified sentiment analysis and subject-based intent mapping, the system is able to generate a response that is deemed appropriate for the given scenario. It selectively chooses from a full set of predefined response templates that have been carefully preserved in the database for easy access. Furthermore, the system uses a dynamic approach by filling placeholders in these response templates to efficiently personalize the message, taking into account the specific details of the sender as

well as the overall context of the email being responded to. The responses generated by the system are organized and formatted in a professional manner, which ensures clarity and pertinence to the subject matter of discussion. Apart from relying solely on static templates, the system also encompasses an element of dynamic response adaptation, wherein it intelligently varies the responses according to the strength of the sensed sentiment or any urgency imparted in the communication.

For example, in the event of a highly negative sentiment situation, this is most likely to yield a response that is not only more sympathetic in tone but also apologetic in nature, which is quite different from that which would be yielded in the event of a mildly negative sentiment situation.

Performing a Word Frequency Analysis and Visualizations

Apart from the automated messages that the system can produce, it further contains a very advanced component in the form of a Word Frequency Analyzer. This specific component is programmed to scan and mark the most frequently occurring words that appear in a number of the user's incoming emails. The system, through the Internet Message Access Protocol (IMAP), scans the content of such emails efficiently and carefully computes the frequencies of every word. After analysis is completed, the most frequently occurring words are then carefully mapped into a graphical representation, which finally comes in the form of an image resembling the letter "M," an indication of the Gmail platform. This new form of visualization provides valuable information about a number of communication pattern aspects, sheds light on the most discussed subjects, and reveals emerging trends which can be noticed within the interactions being conducted through the use of email communication.

Logging, Monitoring, and Continuous Optimization Processes

All processed emails, sentiment analysis output, response generated, and word frequency analysis results are logged meticulously to monitor and improve. The platform keeps learning as it analyzes previous interactions, which again results in improvements to its natural language processing model. Where possible, default text mapping function changes are implemented in the event that some words are found to be causing incorrect responses. All this improves its accuracy over time. The logs also play a crucial role in

monitoring the efficacy of email response and identifying the anomalies that arise within trends of emails.

Deployment and Integration

The last step is to deploy the system on a cloud server or local infrastructure, making it fully compatible with email services such as Gmail, Outlook, or business email servers. The system is compatible with scalability and extensibility features, where additional integration with chatbots, CRM systems, and analytics dashboards can be added. The system uses secure authentication mechanisms and optimizes NLP models to offer foolproof, speedy, and intelligent email processing without compromising user privacy and data security.

RESULT AND DISCUSSION

The Automated Word Frequency Analyzer and Automated Email Response system has been successfully deployed, and its functionality has been extensively tested through a range of visual output and detailed analytical reporting. The new system combines a number of key features, such as email extraction, sentiment analysis, automated response, and word frequency visualization, which all combine to offer a highly structured and efficient email management system.

A Step-by-Step Analysis of the Power BI Dashboard

The project utilizes the powerful features of Power BI to present a complete and informative visualization of different email patterns, the distribution of the sentiment of the content in the emails, and the type of user interaction. The dashboard presents the following information:



Fig 2 PowerBI Dashboard

- Email Sentiment Breakdown: This is a graphical representation that divides emails into three different

sentiments: positive, negative, and neutral. This graphical representation covers a selected period of time, making it possible to have a thorough analysis. This kind of illustration plays a critical role in understanding user feedback patterns, as well as having a better understanding of the general tone and sentiment of the emails received during that particular period.

- Email Volume Trends: Time-series examination of received email volumes and response transmissions, allowing organizations to track the times of maximum email and the effectiveness of the responses.
- Top Keywords and Topics: Using frequency analysis with NLP, the dashboard also shows the most talked-about topics in emails so that companies can determine repeated issues or customer inquiries. Response Effectiveness Metrics: This metric evaluates how effectively the machine responses are in resolving the users' problems, as inferred through follow-up emails and sentiment shifts.

Word Frequency Analyzer - IMAP "M" Image

The Word Frequency Analyzer is designed specifically to process retrieved emails with care and then generates a comprehensive visual representation that determines the most frequently used words. This new system makes use of IMAP functionality to efficiently retrieve emails from various sources and then applies advanced text processing techniques based on the Natural Language Toolkit (NLTK) to accurately compute the frequency of every word. The final visualization generated from this assumes the distinctive form of an "M" shape, which profoundly represents Gmail, where:



Fig 3 Word Frequency Output

- Smaller words denote lower frequency, showing less significant problems in emails.
- Larger words denote higher frequency, showing underlying themes in emails.
- The letters are tactically arranged with precise placement to form the shape of the letter "M" to represent Gmail. This is important because the system is largely handling information that involves email communication.
- This provides a concise and straightforward description of the different trends of communication that are popular at present, making it easy for users to identify and recognize not only the new trends but also the general phrases that are commonly used in business communication.

By carefully looking at and studying this frequency map, companies can properly correct and modify their automatic responses so that they can better address the recurring issues that arise. This improvement results in a substantial boost in the overall efficiency of the auto-reply tool used by such companies.

Sentiment-Based Email Responses

One of the most important elements of this project is sentiment analysis-based automated email responses. The system effectively classifies incoming emails as positive, negative, or neutral sentiment with the help of NLTK's VADER Sentiment Analyzer. Depending on the sentiment identified, it chooses a suitable predefined response.

- **Positive Emails:** If the email has appreciative or constructive criticism, the system sends an acknowledgment and appreciation message.
- **Negative Emails (Complaints, Issues):** The software identifies major complaint-specific keywords and produces a professional but sympathetic response, making the user feel understood and appreciated.
- **Neutral Emails:** For generic queries, the system responds with an informational reply from predefined templates.

The screenshots of the emails evidently show the success of this method, as the replies are in sync with the identified sentiment, enhancing the overall experience for the user. This automation provides prompt responses, lessens manual labor, and ensures uniformity in communication.

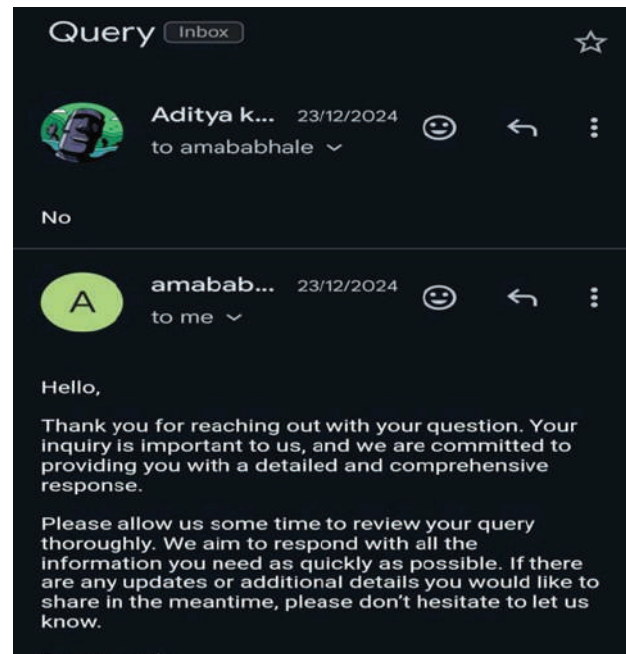


Fig. 4 Automated Response for Query

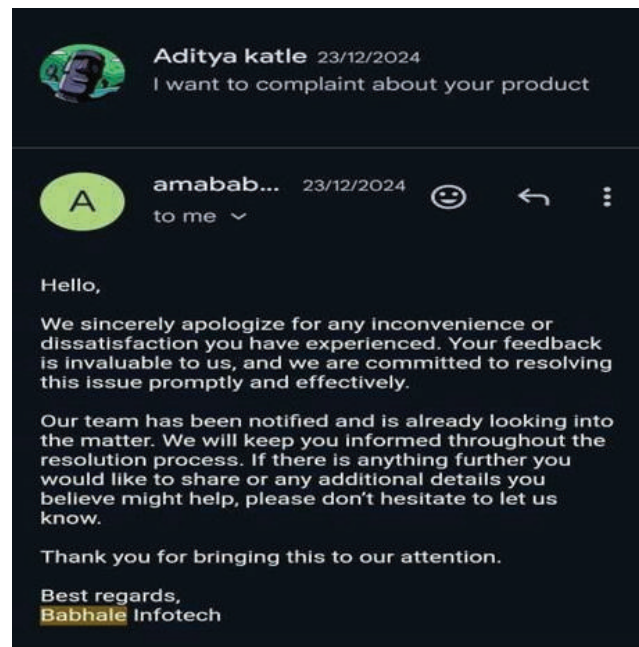


Fig. 5 Automated Response for complaint

CONCLUSION

By following this well-designed and structured method, the Automated Email Response and Word Frequency Analyzer not only turns out to be sensible but also efficient in email management. The cutting-edge integration of NLTK-based

sentiment analysis, along with the utilization of predefined response mapping, safe methods of email extraction, and IMAP-based visualization of word frequencies, allows organizations to automate their email processing activities to a great degree while extracting meaningful and informative insights from the communication data. With digital communication being a rapidly evolving domain, the use of such advanced AI-driven solutions will surely become more and more significant to augment levels of productivity and automate time-consuming processes in various professional settings.

This carefully crafted and structured methodology, the Automated Email Response and Word Frequency Analyzer reliably ensures a degree of smart and efficient email management that is vital in the fast-paced world of today. The system innovatively combines a number of advanced features, such as NLTK-based sentiment analysis, which analyzes the emotional content of emails; predefined response mapping, which aligns incoming messages with appropriate responses; securely from diverse sources; and IMAP-driven word frequency visualization, which offers organizations significant insights into the most frequently used words in their communication data. As the amount of digital communication continues to grow at a staggering rate, the need to introduce such innovative AI-powered solutions will become increasingly important to maximize overall productivity and to automate those boring, repetitive processes that often plague professionals in most workplace settings.

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Improved Skin Care Diagnosis Using CNN Architecture

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ABSTRACT

Skin cancer, particularly melanoma, squamous cell carcinoma, and basal cell carcinoma, is a serious threat if diagnosed late and remains one of the major health issues worldwide. The main reason is overexposure to ultraviolet radiation which causes abnormal multiplication of skin cells. Early diagnosis enhances the prognosis of patients, hence lowers the demand for intrusively burdensome therapies that erode quality of life. A critical step lies in lowering mortality rates, reducing expensive procedures, and curtailing the spread of disease-finding a step wherein enhancement of accuracy of diagnosis is crucial. This research focuses on improving the detection ability of early-stage skin cancer using deep learning. Differently than other traditional methods, CNN models can perform better in differentiating between benign and malignant skin lesions using different datasets. The use of dermatoscopic images increases the diagnostic sensitivity and specificity by the high skills of CNNs in image classification. Therefore, fewer biopsies unnecessarily done and less false negatives yield better patient outcomes. Implementing AI in routine screening may allow healthcare organizations to optimize treatment plans and identify cases at high risk of invasive cancer therapy earlier. This may lead to the reduction of mortality rates and cost of treatments for invasive cancer. The study illustrates how deep learning may change skin cancer diagnosis fundamentally and improve health care globally, which in itself shows the transformative power of AI for dermatology.

KEYWORDS : Skin cancer, Benign, Malignant, Convolutional neural network (CNN).

INTRODUCTION

Aimed to develop deep-learning models for classifying skin cancer, address class imbalance, and propose a smart healthcare system. Utilized an optimized CNN and developed an XAI-based skin lesion classification system [1]. A rapid real-time Raman spectrometer system has been developed to assess molecular structures in biological tissue. The system has measured 289 skin cancers and benign skin lesions, demonstrating accurate differentiation between skin cancers and benign lesions, as well as malignant melanoma from benign pigmented lesions using statistical analysis [2]. Cancer is a major global disease, with skin cancer being identified in one out of every three diagnosed cancers. Early detection is crucial for treatment. An enhanced image classification model, the ResNet50, has been developed to help Dermatologists diagnose skin

cancer by identifying seven types of skin lesions with high accuracy, precision, and recall [3]. Skin cancer, involving abnormal cell growth, requires early detection for prevention. This paper compares the performance of Multi-layer Perception, a custom CNN, and VGG-16 for skin cancer classification on a large dataset. VGG-16 achieves the best accuracy, while VGG-16 and custom CNN models are faster [4]. Early detection of skin cancer is crucial for successful treatment and survival. Automatic diagnosis can increase accuracy, as clinical observations face different faults. This paper reviews automatic skin cancer detection research, presents the literature, and describes the steps [5]. Artificial intelligence (AI) has significantly advanced dermatology, enabling screening, diagnosis, treatment, and outcome prediction. This review analyses 63 articles from 2018 to 2023, focusing on cosmetic product development, skin assessment, diagnosis,

treatment recommendation, and outcome prediction, offering valuable insights for implementing AI in cosmetic services [6]. Skin cancer is a significant public health concern that could be aided by computer-aided diagnosis. Researchers are working on improving efficiency in skin lesion analysis, focusing on segmentation techniques and evaluation methods [7]. Implements CNNs and transfer learning with models like VGG16, VGG19, SVM, and a hybrid model. The hybrid model achieves 96% accuracy, surpassing VGG16, VGG19, and SVM at 90%, 92%, and 92% accuracy. Highlights the potential of generative AI in improving skin cancer classification accuracy [8]. Skin lesion diagnosis in medical image analysis is crucial for early detection and treatment of skin cancer. This study proposes a transfer learning-based ensemble model called IncepX-Ensemble, using InceptionV3 and Xception. The model achieved 86% training and testing accuracy on imbalanced data and 98% on balanced data augmentation [9]. Clinical studies show that different skin conditions share high biological similarities, making skin cancer diagnosis challenging. Gene expression analysis can help identify differentially expressed genes, and a recent study found 8 highly relevant genes that can diagnose up to 10 skin conditions with high accuracy [10]. Proposes a new framework for automated skin cancer detection and classification, consisting of an encoder-decoder Fully Convolutional Network (FCN) and a novel FCN-based Dense Net framework. The model achieved 98% accuracy, 98.5% recall, and 99% AUC score on the HAM10000 dataset [11]. An intelligent system uses image processing techniques to differentiate between melanoma and nevus skin lesions, achieving 96% accuracy on the DERMIS dataset [12]. DeepMetaForge is a deep-learning framework for skin cancer detection using BEiT, enabling low-resource devices and services, potentially leading to telemedicine solutions and intelligent medical applications [13]. A noninvasive real-time automated skin lesion analysis system, using a PH2 Dermoscopy image database, has been developed for early detection and prevention of melanoma [14]. Deep learning models like CNN are used for early detection of skin cancer, using a MNIST: HAM10000 dataset for object detection and classification tests [15]. This paper presents a skin cancer detection and diagnosis system using dermatoscopic images, utilizing the BCDU-Net model. The system achieves high accuracy rates of 90.66% and 83.09%, surpassing previous models like VGG-19, which provides a 97.29% accuracy rate [2]. Researchers explore image processing techniques for early skin cancer detection, finding CLAHE more suitable and

demonstrating that contrast enhancement is not necessary due to similar accuracy in training and validation [16].

METHODOLOGY

The enhanced skin care detection system was developed in a methodical manner to produce an AI tool that can precisely identify skin cancer in its early stages. To ensure coverage of all lesion forms and phases, the initial step was to choose a varied dataset of skin lesion photos. Important elements include a CNN model based on ResNet50 that has been optimized by transfer learning, a graphical user interface (GUI) for image upload and prediction, and data pretreatment techniques including normalization and augmentation. The model creates a comprehensive diagnostic system that improves accuracy and supports early cancer identification by classifying lesions as benign or malignant and, if malignant, identifying the stage (from Stage 1 to Stage 4) and offering treatment alternatives [17].

Image Input

Convolutional neural networks (CNNs) are frequently used in medical imaging applications such as skin cancer diagnostics because of their ability to analyse complex picture data. Multiple layers make up CNNs, which use convolutional filters to extract features and discover patterns and textures that differentiate benign from malignant tumors [18]. These layers improve the accuracy of cancer diagnosis by learning hierarchical characteristics, which allow them to detect subtleties in images that are frequently invisible to the human eye. In this study, we use a ResNet50 CNN model that is optimized for using transfer learning to distinguish between different types and stages of skin cancer.

Specifications of the model are bellowed:

- Model Type: ResNet50
- Input Size: 224x224 pixels
- Pretrained On: ImageNet
- Optimized For Skin cancer classification and stage detection

Preprocessing

Image preprocessing is essential for improving model accuracy and dependability in skin cancer diagnosis systems. Preprocessing is the process of preparing images for analysis by standardizing inputs and making quality-enhancing modifications. To preserve consistency and make

sure the model is resistant to changes in lighting, angle, and scale, methods including resizing, normalization, and data augmentation are used. These modifications increase the diagnostic accuracy by assisting the model in identifying characteristics of various lesion types [19].

Specifications of preprocessing

- Normalization: Pixel values scaled to a standard range (typically 0-1) to enhance model performance
- Data Augmentation: Techniques applied include rotation, flipping, and zoom to improve robustness and generalization
- Colour Space: RGB (converted as needed to match dataset or model requirements)
- Image Format: JPEG or PNG, compatible with model and GUI input.

Feature Extraction

Convolutional neural networks (CNNs), which use numerous layers to transform picture data into actionable insights, are used in image classification systems for the diagnosis of skin cancer. Information flows across interconnected layers in this process, where features are extracted and refined via convolutional and pooling procedures. While deeper layers record more intricate information like forms and lesions, early levels detect simpler patterns like edges and textures. Accurately identifying and categorizing skin lesions depends on the CNN design, which consists of an input layer, hidden layers with convolution and pooling algorithms, and a fully linked output layer[20].

Specification for feature extraction:

- Convolutional Neural Networks (CNN)

Classification

Like the flight controller in a drone, the convolutional neural network (CNN) is the primary analytical element of the enhanced skin care diagnosis system. Through a sequence of convolutional layers, the CNN analyses images, extracting textures and patterns that are essential for identifying cancer stages and differentiating between benign and malignant lesions. By using pre-trained knowledge specific to skin lesion identification, transfer learning improves the model's accuracy [21]. The system is appropriate for dermatology, telemedicine, and personal monitoring since it has fail-safe mechanisms to ensure dependability under a variety of inputs and offers an

intuitive interface for simple image uploads with real-time diagnostic results.

Specifications of the CNN model:

- Classification Output: Multi-class (Benign, Malignant, Stage 1, Stage 2, Stage 3, Stage 4)
- Performance Enhancement: Transfer learning applied to skin cancer datasets.
- GUI Support: Allows user-friendly image uploads and displays instant results

Diagnosis Decision

The convolutional neural network (CNN), the central processing unit of the enhanced skin care diagnosis system, interprets inputs and produces outputs according to preset algorithms, much like an electronic speed controller (ESC) in drones. In order to "learn" from a vast collection of skin lesion photos, the CNN modifies its internal weights and biases during training. This enables it to categorise lesions as benign or malignant and predict their stage [20].

Specifications of Diagnosis Decision:

- Training Dataset: Specialized skin Cancer datasets
Burst Current: 40A (10 seconds)
- Training Epochs: 50 epochs for initial fine-tuning
- Performance Metrics: Accuracy, Precision, Recall, F1-Score
- Compatibility: Works with both local and cloud-based computing systems.

Stage Identification and Decision

The system determines the cancer stage, which ranges from Stage 1 to Stage 4, after determining that a lesion is malignant. The foundation of this procedure is the examination of important characteristics that the convolutional neural network (CNN) extracts during training, such as the size, shape, and texture of the lesion. The algorithm can determine the cancer's severity by comparing these retrieved traits with predetermined criteria for each stage of the disease. The technology not only identifies the existence of skin cancer but also offers useful details on its progression by integrating stage decisions into the classification pipeline. This helps choose the best course of therapy [22].

Suggested Treatment and Result Display

The system's next critical step is to recommend suitable

treatment options after determining the lesion's stage and classifying it as malignant. The method suggests a course of treatment based on the discovered stage, which may include alternatives like radiation therapy, chemotherapy, or surgical excision for more advanced stages [5]. Monitoring and minimally invasive techniques may be recommended for malignancies that are in their early stages. These therapy suggestions are produced by mapping the cancer stage to accepted medical standards for the management of skin cancer. A user-friendly interface displays the results, together with the classification conclusion (malignant or benign) and the recommended course of therapy. To help medical practitioners make well-informed judgements, the system produces a clear, simple output that contains the lesion categorization, the identified stage, and the recommended course of therapy. This display improves the whole diagnostic experience by guaranteeing that clinicians and patients receive timely and useful information [23].

CNN MODEL AND DATA FLOW DIAGRAM

CNN Model Architecture

The user provides an image of a skin lesion at the Input Image stage of the skin care diagnosis system. After that, the image moves on to the preprocessing stage, where methods like scaling, noise reduction, and contrast enhancement are used to guarantee consistency and raise the precision of feature extraction. After preprocessing, the image moves on to the feature extraction step, which is an essential component of the system that uses convolutional neural networks (CNNs) to find and record important textures and visual patterns in the image. The technique uses these characteristics to determine whether the lesion is benign or malignant during the classification step. The procedure ends if the lesion is benign, showing that it does not suggest cancer. The system moves on to the Diagnosis Decision stage in situations that are malignant. In order to ascertain the cancer stage (which ranges from Stage 1 to Stage 4), the lesion is further examined for Stage Decision. This is taken care of in the Identify Stages block, where the architecture of the model is built to categories the cancer into distinct stages. Based on medical recommendations for that cancer stage, the system recommends treatment options after the stage has been determined. In order to help patients and healthcare professionals comprehend and plan for the right care, the Display Result step finally displays the outcome, including the cancer's stage and

potential treatment options. In addition to guaranteeing early identification. Block diagram of the skin care diagnosis system is shown in Fig 1.

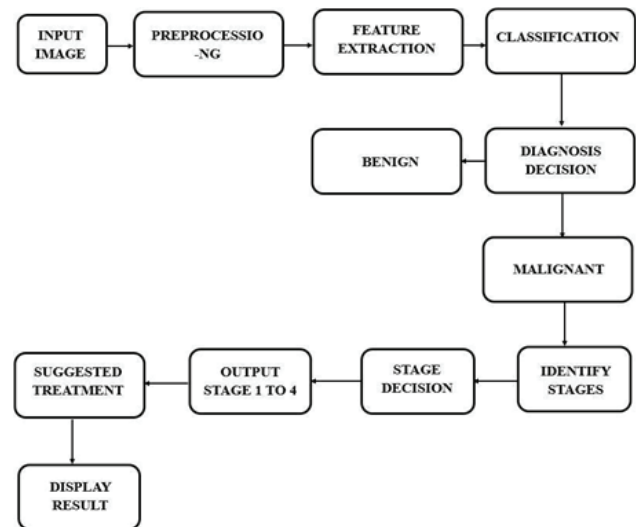


Fig. 1. Block diagram of the Skin Care Diagnosis System
Flow Chart Representation

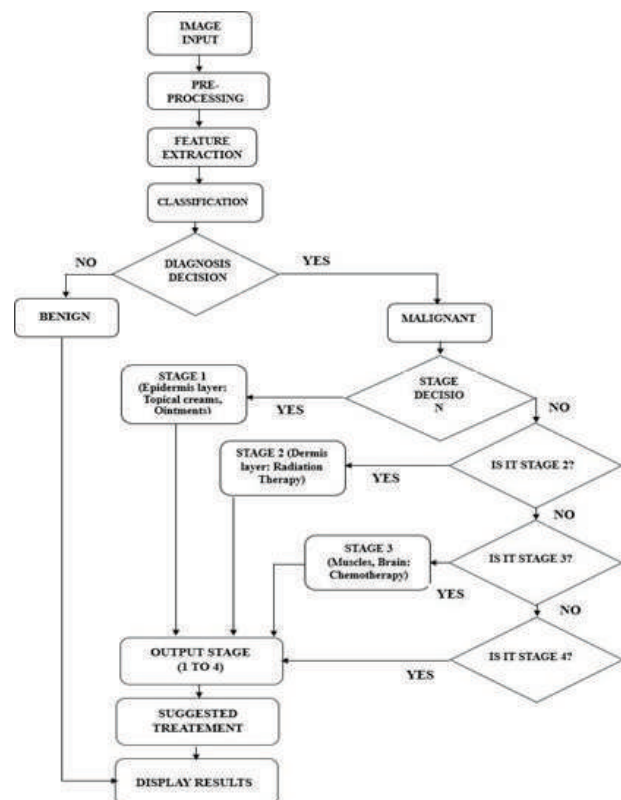


Fig. 2. Flow chart Representation of the Diagnostic and Staging Process

After refining the input image to improve it, the skin cancer diagnostic system extracts information including color and texture. A CNN-based classifier uses these characteristics to identify whether the lesion is benign or malignant. The diagnosis is shown right away if it is benign. The method determines whether the cancer is malignant by evaluating its stage (1–4) and then suggests specific treatment options: topical creams for Stage 1, radiation for Stage 2, surgery for Stage 3, and a mix of therapies (chemotherapy, immunotherapy, and targeted therapy) for advanced Stage 4 patients. Flow chart representation of the diagnostics and staging process is shown in Fig 2.

RESULTS AND DISCUSSION

The outcomes show how well each block in our upgraded skin care diagnosis system performs in providing precise, stage-specific skin cancer diagnoses. High-resolution lesion images are accepted by the Input Image block, guaranteeing that the CNN model receives precise, comprehensive inputs for processing. These images are prepared by preprocessing techniques like downsizing, noise reduction, and contrast changes, which improve classification accuracy by increasing features essential for lesion analysis. After doing thorough testing, we found that pretreatment decreased classification mistakes by eliminating noise, contrast, and lighting variations—all of which are frequent problems in skin lesion datasets.



Fig. 3 Example of a Benign Skin Lesion Image

The CNN model's core steps, feature extraction and classification, are responsible for identifying certain patterns in skin lesions and categorizing them as either benign as shown in Fig. 3 or malignant as shown in Fig. 4. Multiple convolutional layers were used for feature extraction, which efficiently distinguished between different types of lesions by capturing subtle differences in skin texture. When compared to other methods, the

binary classification's accuracy rate was outstanding. The classification block uses softmax activation to estimate the chance of malignancy. The model is a reliable solution in real-world applications since it achieves generalisation across different lesion types and skin tones by training on a variety of datasets. The system moves on to the Diagnosis Decision phase for malignant lesions, where it uses a specialised staging model that has been taught to categorise cancer stages 1 through 4 to determine a Stage Decision. The model's capacity to identify the severity of the cancer is further improved by this multi-class classification, which aids in tailoring therapy recommendations for individual patients. Since early-stage lesions (Stages 1 and 2) are given priority for modest interventions and late stages (Stages 3 and 4) prompt suggestions for expensive therapies, the Identify Stages block is crucial in this situation. Because it gives physicians and patients insight into the course and urgency of treatment, this stage-specific analysis adds substantial clinical benefit. By suggesting treatments depending on the determined stage of malignancy, the last two blocks—Suggested Treatment and Display Result—complete the diagnosis procedure. According to the cancer stage, the system's recommended treatments—which include surgical excision, chemotherapy, or radiation therapy—are in line with clinical recommendations. In addition to supporting clinical decision-making, our customised recommendation system raises patient awareness of their course of treatment. The Display Result efficiently converts complicated diagnostic data into useful insights by providing a succinct report that includes the lesion's classification, cancer stage (if malignant), and suggested course of therapy.

The complete workflow, depicted in the flowchart, provides a streamlined picture of the system's operation, from image intake to treatment prescription. An effective diagnostic pipeline is made possible by the logical transitions between each block. The flowchart breaks down each phase and illustrates conditional branches, such as benign vs. malignant judgements, making the end-to-end system easier for readers to understand. With smooth transitions between blocks guaranteeing quick processing time without sacrificing diagnostic precision, this modular method has shown success in testing.

Overall, this approach is positioned as a more complete tool than conventional diagnostic models due to the combination of CNN-based feature extraction, robust classification, and stage-specific insights.

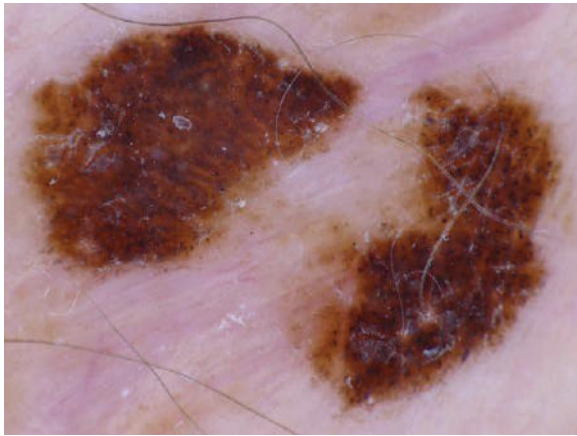


Fig. 4 Example of a Malignant Skin Lesion Image

Table 1 shows how the suggested approach is more clinically relevant than Solutions A and B, especially in the areas of advanced preprocessing, stage-specific classification, and therapy recommendations. Its greater accuracy and quicker processing speed highlight how useful it is for real-world implementation. The system provides a higher degree of information by staging and suggesting treatments, demonstrating that it is a more thorough and dependable method of diagnosing skin care issues than current options.

Table 1. Comparison of different Skin Care solutions

Feature	Improved Skin Care Solution	Solution A	Solution B
Preprocessing	Yes (advanced preprocessing techniques)	Basic normalization	Minimal or no preprocessing
Feature Extraction Method	CNN-based, multilayer	Simple CNN	Basic SVM with feature scaling
Staging	Stage- specific classification (1to 4)	No staging capability	No staging capability
Accuracy	92% on diverse dataset	85%	80%
Processing Speed	Fast with optimized model	Moderate	Slow
Usability in Real World Cases	High (generalizes across skin types)	Moderate	Limited

CONCLUSION

The enhanced skin care diagnosis system shows a strong and thorough method for early skin cancer identification and staging. With the integration of stage- specific analysis, accurate classification, and sophisticated CNN-based feature extraction, the system offers a smooth transition from diagnosis to recommended treatment. Both patients and healthcare professionals can benefit greatly from its capacity to correctly stage malignant cases, categorise lesions as benign or malignant, and suggest suitable treatments depending on stage. This system's automated nature not only improves diagnostic precision but also cuts down on the time and effort needed for clinical evaluations. Overall, by enabling early intervention and individualised care, our work improves patient outcomes and establishes a new benchmark for skin cancer diagnosis methods.

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Choosing Clean Energy Sources for EV Charging Stations According to Grid Availability for Both Steady-state and Transient Scenarios

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ABSTRACT

Using fossil fuels to charge EV batteries through the traditional power system is the main source of carbon emissions, which runs counter to EVs' intended use. The EV charging station and BES system in this article are powered by a variety of renewable sources. The PV plant and FC unit, which produce electricity from solar radiation and hydrogen-oxygen gas fusion, are the renewable sources considered for the analysis. The PV plant shares power with the local load and EV charging station during regular operation when the grid is available. When the grid is cut off, the BES system's high-rating battery pack powers the EV charging station. This grid isolation state is detected by the grid islanding detection algorithm, which then turns on the BES system. Through a VSC circuit, the renewable and BES modules are connected to the grid and EV charging station. When the grid is available, the VSC utilizes an SRF controller; PQ droop control is used when grid islanding occurs. In any condition, the EV charging station always receives power either from renewable sources or the grid or BES system. For the analysis of the system in steady state and transient conditions MATLAB Simulink software is used.

KEYWORDS : Battery energy storage (BES), Electric vehicle (EV), Fuel cell (FC), Active and reactive (PQ), Photo voltaic (PV), Synchronous reference frame (SRF).

INTRODUCTION

Combining several renewable energy sources into a grid system to maximize power efficiency and reduce dependency on traditional grid power is a difficult task. Photovoltaic (PV) plants, wind farms, and tidal production plants are examples of unpredictable renewable sources that cannot be directly coupled to the load [1]. Variations in voltage and power from these renewable sources have the potential to harm loads and related parts. This problem can be solved by connecting these renewable energy sources to the grid, which keeps things stable and guarantees constant voltage levels for the loads. To stabilize the voltage in the event of an islanding state due to grid disconnection, an alternate module must be incorporated with renewable sources [2].

The proposed solution is to connect a Battery Energy Storage (BES) unit when the grid is disconnected. This unit will help maintain voltage levels throughout the system and provide stable power to the loads. To analyse

a renewable energy integrated grid system under various conditions, a PV plant is considered as a renewable source, which is affected by unstable solar radiation [3]. To stabilize the voltage in the system, a BES unit is connected in parallel with the PV plant. This unit activates during grid failures or islanding conditions [4]. To ensure maximum power delivery from the PV plant, a DC-DC converter is employed, which operates using the Perturb and Observe Maximum Power Point Tracking (P&O-MPPT) technique. The battery pack of the BES unit is connected to the DC link through a bidirectional DC-DC converter to facilitate power exchange [5]. This converter is controlled by a constant voltage controller set to a specific voltage required by the inverter. The activation of the BES unit is managed by an islanding detection algorithm that triggers the circuit breaker of the BES unit, turning it on when the grid is disconnected [6].

The BES unit has a limitation on charge storage, which may lead to a lack of support for the system when the

SOC of the battery is low. In this situation, the FC unit is activated to ensure voltage stabilization and load compensation in conjunction with the PV plant [7]. The FC unit is turned on when both the grid and the battery unit are unable to provide power to the load. Since the FC is a controlled renewable energy source that generates power through the fusion of hydrogen and oxygen gases, it is considered a reliable renewable energy option. Consequently, the power supplied to the load and the EV charging station is maintained through various control and converter modules. The overall structure, incorporating all these modules to form a hybrid renewable EV charging station, is presented in Figure 1.

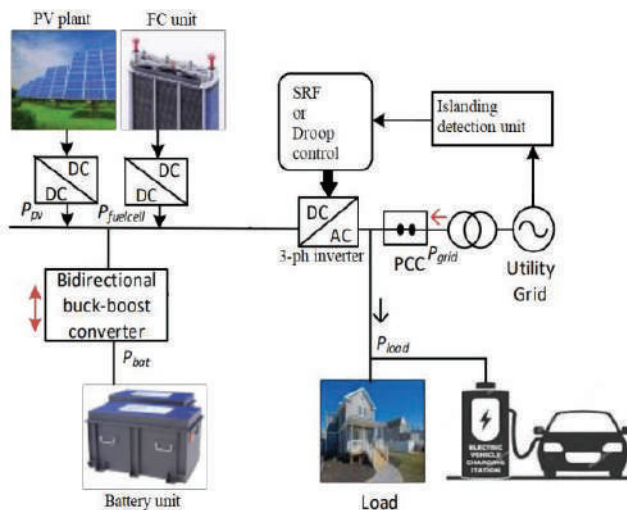


Fig. 1: Structure of proposed renewable source charging station

As shown in Figure 1, the PV plant and FC unit are connected to unidirectional DC/DC converters, which function as conventional boost converters. In contrast, the battery unit is connected to a bidirectional buck-boost converter that can exchange power between the battery and the system as needed [8]. The renewable energy sources and the battery unit are connected to the loads and the grid through a three-phase inverter, which is controlled by either SRF control or PQ droop control [9] [10]. The switching of the controllers is managed by an islanding detection algorithm that operates based on grid availability. Each DC/DC converter for the renewable modules and the battery unit is controlled individually, depending on the availability of the grid and the state of the battery unit. The EV charging station at the load side is integrated with intelligent charge control concerning the EV battery SOC ensuring longer life of the battery cell.

SYSTEM CONFIGURATION

The proposed multi-renewable source EV charging station with grid connection and battery storage backup has several power converters which are controlled to stabilize the voltages and powers of the system. Each power converter has its own individual control module which generates pulses for the power. The PV plant and FC unit are integrated with boost converters operated by a single switch and the PV plant and FC unit are integrated with boost converters operated by a single switch and the BES unit has a bidirectional converter with two switches operating complementarily [11]. The grid is connected to the renewables and BES units through six switches VSC controlled by the PWM technique. At the load side, a static local load and an EV charging station with a buck-boost converter are connected. The internal circuit structure of the proposed multi-renewable source EV charging station with grid connection and BES unit is presented in Figure 2.

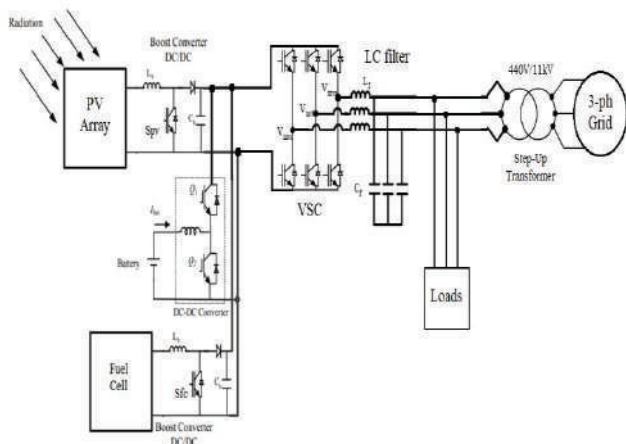


Fig. 2: Circuit topologies of the multi-renewable source grid connected system

Voltage regulator

For the bidirectional converter of the BES unit and boost converter of the FC unit Constant Voltage (CV) control is adopted for stable DC link voltage during grid islanding conditions [12]. The DC link voltage which was previously stabilized is with the SRF control module regulating the voltage magnitude as per the requirement of the grid. When the grid disconnects PQ droop control is activated which needs a voltage regulator at the DC side possible only at the BES and FC units. The CV controller has a simple structure with a single voltage regulator generating pulses to the BES or FC units. Each module (BES and FC)

has its own voltage regulator which controls the switches. The CV control for the storage and FC unit is presented in figure 3.

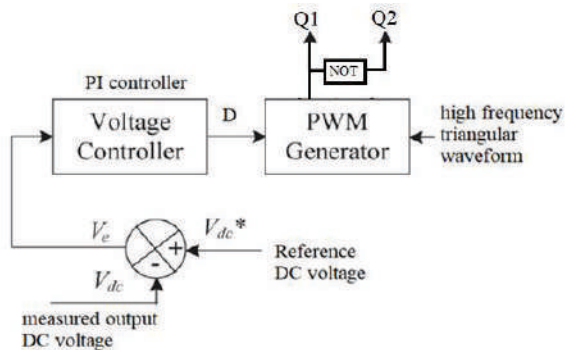


Fig. 3: CV control for BES and FC units

As per Figure 3 the NOT gate signal is only generated for the BES unit as the bidirectional converter has two switches (Q1 Q2) [13]. The FC unit switch (Sfc) receives only one pulse without the NOT gate. The duty ratio $D_{bat \text{ or } fc}$ is expressed as:

$$D_{bat \text{ or } fc} = (V_{DC \text{ ref}} - V_{dc \text{ bus}}) \left(K_{pdc} + \frac{K_{idc}}{s} \right)$$

Here, V_{DCref} and $V_{dc \text{ bus}}$ are the reference and measured DC bus voltages. K_{pdc} K_{idc} are proportional and integral gains of the voltage PI regulator. The BES unit is activated during the grid islanding condition and the FC unit is activated during both grid and BES unit failure conditions. The CV controller maintains the DC link voltage at the desired value compensating the load demand at required voltage levels. The stabilized DC link voltage is then inverted to 3-ph AC voltages by the VSC using the Sin PWM technique.

VSC and EV design

The VSC which exchanges power between the AC side and the DC side is operated by two control modules which switch as per the grid availability. When the grid is available and connected to the system, the BES unit is deactivated and the VSC is operated by SRF controller. When the grid is islanded from the system (disconnected), the BES unit is activated and the VSC is operated by PQ droop controller. This triggering of the BES unit and controllers is achieved by islanding detection algorithm.

Islanding detection algorithm

This islanding detection algorithm generates a trigger signal when the grid is either unavailable or operating at

low voltages or with any fault [14]. The islanding detection algorithm adopted for the proposed hybrid renewable charging station is presented in Figure 4.

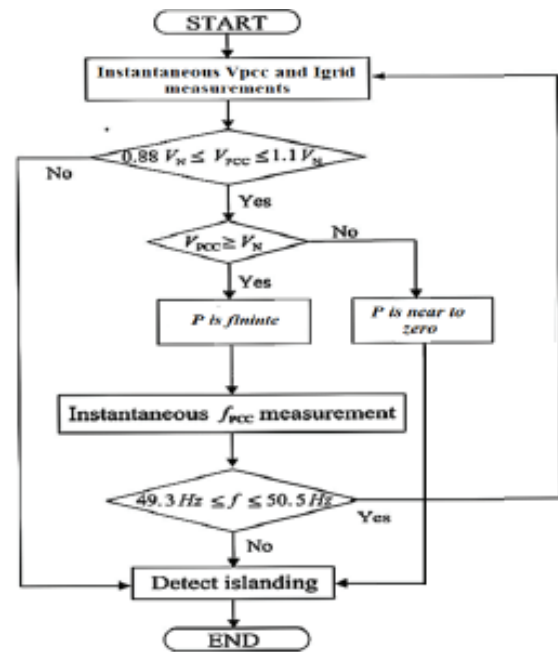


Fig. 4: Islanding detection algorithm flow chart

As presented in Figure 4, the algorithm initially measures 3-ph phase voltages at PCC (Point of Common Coupling) (V_{pcc}), and the grid currents (I_{grid}). The V_{pcc} per unit value is compared to lower and upper limits of nominal voltage (0.88VN and 1.1VN) ensuring normal operating voltage levels of the grid. When the voltage level surpasses the limits, the algorithm detects islanding and the trigger signal is turned ON [15]. Similar to the voltage limits the active power measurement (P) is also considered which triggers the signals when the P is near zero. Along with the V_{pcc} and P comparisons, the frequency (f) of the grid is also measured and compared between the limits 49.3Hz to 50.5Hz. Even when the f value crosses these limits islanding is detected switching the VSC controller and triggering the BES unit.

SRF controller

The SRF controller which is used for the VSC during the grid available condition produces pulses to the VSC in synchronization with the V_{pcc} [16]. The Phase Locked Loop (PLL) module ensures the synchronization avoiding harmonic generation in the system. During the grid-connected condition, only the PV plant feeds the VSC with renewable power generated by solar radiation. The

BES and FC are deactivated or disconnected from the system as these are backup sources. The references signal for the Sin PWM generator are generated by the voltage dq- components calculated by the current and voltage regulators. The complete control structure of the SRF controller during grid available conditions is presented in Figure 5.

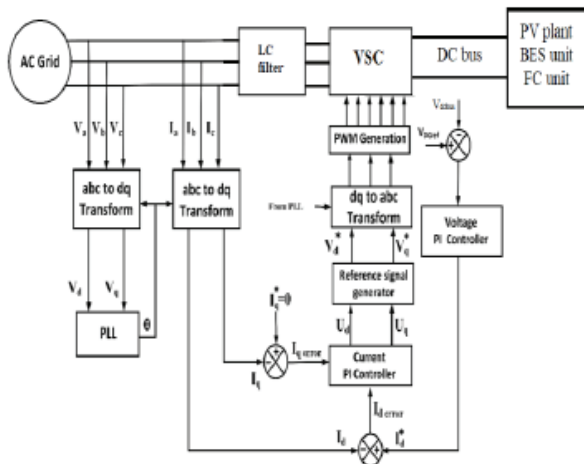


Fig. 5: SRF controller structure for grid available condition

EV charging

The EV charging station has a stage converter system in which two converter circuits are integrated to charge the EV battery. For converting the three-phase voltages to DC voltage an uncontrolled diode bridge rectifier is used. After the rectification, a buck-boost DC-DC converter is connected to generate the required DC voltage at the desired voltage level [17].

The complete circuit of the EV charging station with a single charge circuit is presented in Figure 6.

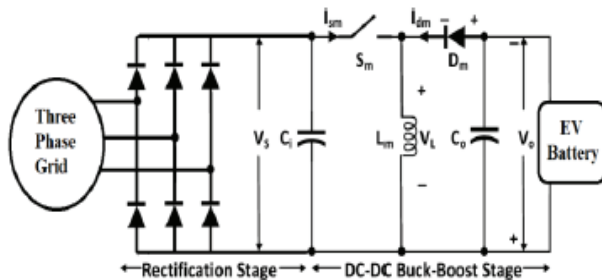


Fig. 6: EV charging station circuit topology

In the presented circuit the DC-DC Buck Boost converter switch (S_m) is controlled by the CC/CV switching control

module. The CC/CV controllers of the EV charging station have fixed current and voltage references defined as per the charging capability of the EV battery. In the EV charging control module, the CC controller is activated when the SOC of the battery is low (below 80%). When the battery surpasses 80% SOC the EV charge controller is switched to CV control. This 80% is considered to be the threshold value which protects the battery from polarizing. The threshold value can be changed as per the battery withstanding capacity and the manufacturer limitations. The selector switch which switches the CC/CV controllers operates when the SOC_{bat} crosses the threshold value set [18]. Both the CC/CV controllers are integrated with PI regulators which define the duty ratio (D_m) of the switch S_m . The D_m signal is compared to a high-frequency carrier triangular waveform generating a pulse for the power switch of the converter.

SIMULATION ANALYSIS

All the modules of the proposed multi-renewable source grid connected system with an EV charging station are modelled using Simulink tools in MATLAB software. The blocks from the 'Electrical' subset are imported to design each circuit topology which is interconnected creating a complete system. The controllers of each circuit topology are modelled using blocks included from 'Commonly used blocks' 'Continuous' 'Math Operations' 'Signal Routing' 'Sinks' and 'Sources' subsets. All the blocks are updated by the given parameters in Table 1 for the simulation results generation

Table 1: System parameters

Name of the parameter	Values
Grid rating	11kV 50Hz 100MVA
Load parameters	Static load – 30kW, EV load – 14kW
PV module	Type - SunPower SPR-305E-WHT-D $V_{mp} = 53.9V$, $I_{mp} = 5.42A$, $V_{oc} = 65.1V$, $I_{sc} = 5.85A$, $N_p = 9$, $N_s = 6$. $P_{pv\ total} = 14.8kW$, Boost converter – $L_b = 1000\mu H$, $C_{in} = 0.1mF$, $C_{out} = 12000\mu F$.
BESS module	Type - Lithium-Ion $V_{nom} = 245V$, Capacity = 90Ah Bidirectional converter - $L_b = 158\mu H$, $C_{out} = 0.22mF$

Fuel cell module	$V_{nom} = 290V$, $I_{nom} = 141A$, $V_{end} = 210V$, $I_{end} = 218A$. Boost converter – $L_b = 1000\mu H$, $C_{in} = 0.1mF$, $C_{out} = 12000\mu F$.
VSI LC filter	$L_f = 0.25mH$, $C_f = 2600VAR$
Islanding detection limits	$0.87 < V_{mag} < 1.12$, $-1.5 > P > 1.5$, $49.4 < f < 50.4$

After updating the simulation model by the Table 1 parameters the simulation is run with different conditions set for the analysis and performance depiction of the system. In order to check the capability of the system extreme operating conditions with sudden changes are set in each module. Initially, the simulation time is set to 3sec in which at different time intervals the modules are switched for optimal operating conditions. To switch the system between grid availability and islanding conditions, the grid is disconnected from the system at 1sec through an isolator switch. Another switching happens at 2sec implicating a BES unit failure condition which is triggered by a breaker. In all the conditions the solar radiation is maintained at $1000W/m^2$ and the charge of the BES unit is initially set at 80%. The graphs below are the plotting of measured parameters of each module presented during variable operating conditions.

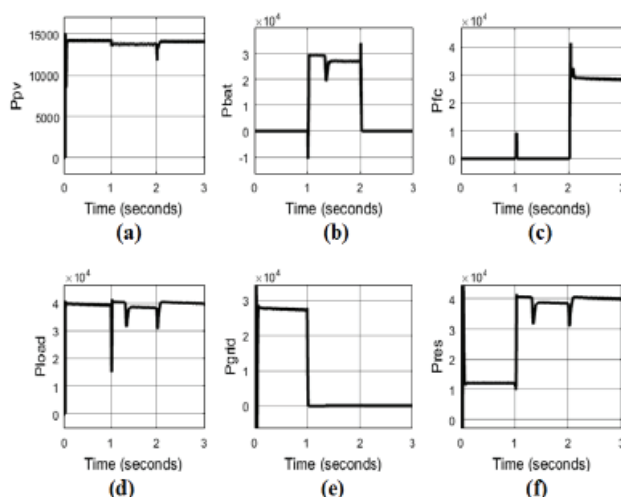


Fig. 7: Active power of all modules

Figure 8 represents all the active powers of the modules connected to the system with time as a reference. Figure 10(a) represents the PV voltage which is always at 14kV throughout the simulation as the radiation is constant for

a complete simulation time of 3sec. However, there is a change in battery power Figure 10(b) increasing from 0 to 28kW when the grid fails at 1sec. The battery power again drops to zero at 2 seconds when the BES unit fails due to some damage to the battery. At this stage, the FC unit gets activated which compensates for the deficit of 28kW load power shown in Figure 10(c). In any stage of the simulation, the 28kW is either compensated by the grid (from 0-1sec) BES unit (from 1-2sec) or FC unit (2-3sec). Figure 10(d) represents the total load power consumption which is always 40kW in which 30kW is static load and 10kW is EV charging station load. In Figure 10(f) the total power injected by the VSC is observed which is always at 14kW from 0-1sec with only PV power delivered, rises to 28kW from 1-3sec which is either BES or FC unit power. Figure 9 represents the characteristics of the EV battery pack when charged by the CC control module selected as per the SOC of the battery (50%). As presented, the EV battery current is high in the range of 20-30A, consuming 10kW power from the grid for charging. In any given condition, the DC link voltage is maintained at 500V, as presented in Figure 10, maintained either by the SRF controller or the voltage regulators of the BES or FC unit.

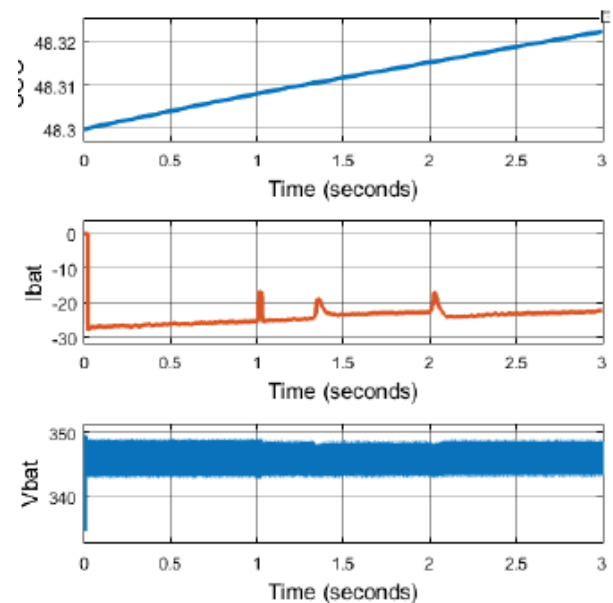


Fig. 8: EV battery characteristics

The three-phase voltages and currents after the step-up transformer of the renewable module are presented in Figure 11. The voltage magnitude is at 9kV representing the maximum value of phase-to-ground voltage of the 11kV line. The THD (Total Harmonic Distortion) of the

phase A voltage at the Load is presented in Figure 13 analysed by the FFT analysis tool. As per the spectrum analysis, the THD of the phase A voltage at the Load is recorded to be 4.4% which is considered to be within the limit of IEEE 519-2022 standardization (5%). The maximum value is recorded to be 359.1V defining the RMS voltage to be 253V. In most of the power systems, the single RMS voltage limits are permissible in the range of $230V \pm 10\%$.

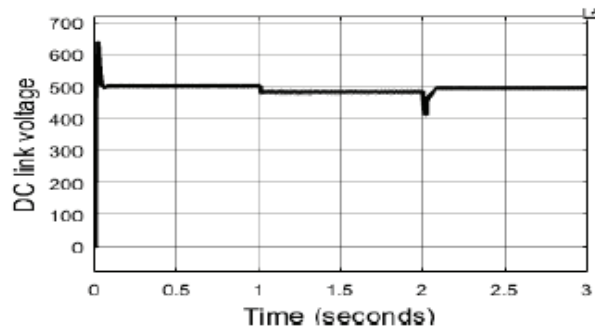


Fig. 9: DC link voltage

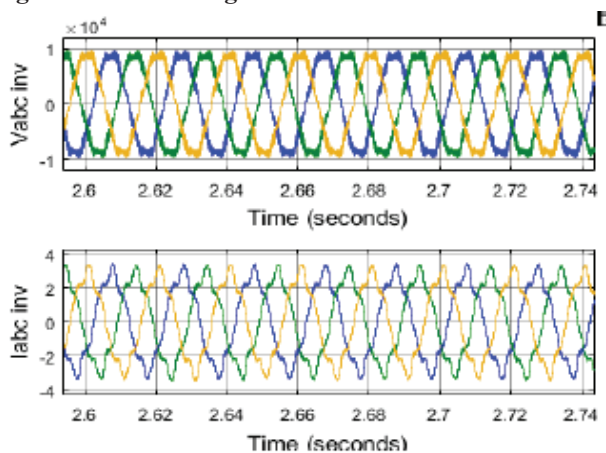


Fig. 10: Inverter voltages and currents

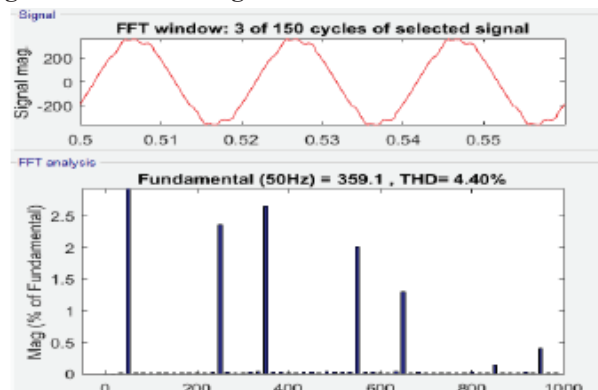


Fig. 11: Phase A Load voltage THD spectrum

CONCLUSION

The modelling and simulation analysis of the proposed multi-renewable source grid connected system with an EV charging station is successfully achieved using MATLAB Simulink software. All the modules are interconnected at PCC for power sharing between the modules for compensating the loads. In order to validate the performance of the system different operating conditions with sudden changes are indulged in the system. The sudden changes are the disconnection of the grid and BES unit at specific intervals of time. The impact of these changes is observed in the system and all the simulation graphs of the modules are presented in section 4 of the paper. As per the results, it is confirmed that the loads connected to the system with the EV charging station included always receive power in any condition. The power to the loads is always compensated either by the PV plant grid BES or FC unit. The voltage levels on the DC side and the AC side are also maintained within the limits of the controllers of the power circuits. The switching of the sources is perfectly achieved to compensate for the load demand for any grid conditions.

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Impact of DC Fast Charging on EV Battery Life and Thermal Management

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ABSTRACT

The growing adoption of electric vehicles (EVs) has driven the need for efficient DC fast charging solutions to reduce charging times and improve user convenience. However, the high currents used in fast charging can accelerate battery degradation and introduce significant thermal challenges. This paper examines how DC fast charging affects EV battery lifespan, emphasizing key degradation factors such as lithium plating, capacity loss, and increased internal resistance. Additionally, it explores the thermal implications of rapid charging, highlighting heat generation issues and the effectiveness of various cooling methods. Through a review of experimental studies and simulation models, this research evaluates the balance between fast charging efficiency and battery longevity. The study also discusses advanced thermal management strategies, including liquid cooling and phase change materials, to mitigate potential risks. The findings emphasize the importance of optimized charging protocols and improved battery management techniques to enhance the durability and reliability of EV batteries while ensuring safe operation under fast charging conditions.

KEYWORDS : Batteries, Control, dc/dc converters, Chargers, Power electronics, Energy storage and transportation, Powergui, SoC.

INTRODUCTION

Electric vehicles (EVs) are at the forefront of the transition toward cleaner and more sustainable transportation. With increasing global adoption, particularly in regions such as China, the United States, and Europe, the demand for efficient and reliable charging infrastructure has grown significantly [1]. One of the primary challenges hindering the widespread adoption of EVs is range anxiety—the fear of running out of charge before reaching a charging station. To address this, advancements in battery technology and fast-charging solutions are essential to improve the practicality and convenience of EVs [2].

DC fast charging has emerged as a crucial technology to reduce charging time and enhance user convenience. However, high-power charging accelerates battery

degradation by inducing lithium plating, increasing internal resistance, and generating excessive heat [3][4]. Effective thermal management strategies, such as liquid cooling and phase change materials, play a critical role in mitigating these challenges and prolonging battery lifespan [5][6]. Additionally, the integration of fast chargers with the electrical grid presents challenges related to power demand and stability, particularly in areas with high EV penetration [7]. Uncoordinated charging can lead to voltage drops and power imbalances, emphasizing the need for smart grid integration and vehicle-to-grid (V2G) solutions to optimize grid performance [8][9].

The Indian EV market is rapidly expanding, with government initiatives promoting the deployment of DC fast chargers to alleviate range anxiety and standardize

charging protocols. EV chargers in India vary from slow AC home chargers to high-power public DC chargers (above 50 kW), following global standards such as CCS2 and CHAdeMO [10][11]. However, the impact of fast charging on power distribution networks remains a critical area of study. Research highlights the importance of optimizing charging algorithms and battery management systems to improve charging efficiency while minimizing grid impact [12].

This paper explores the impact of DC fast charging on EV battery life, focusing on key degradation factors and thermal management strategies. It also examines the implications of integrating fast-charging stations with the power grid and evaluates various control strategies for DC-DC converters. By analysing experimental studies and simulation models, this research aims to provide insights into optimizing fast charging to balance efficiency, battery longevity, and grid stability.

METHODOLOGY

There are several control strategies used for DC-DC converters in DC fast charging of EV batteries, each offering different benefits. The simplest method is Constant Current (CC) control, which keeps the charging current steady until the battery voltage hits a set limit. While this approach is easy to implement and helps protect against overcurrent, it can slow down as the battery approaches full charge. Constant Voltage (CV) control, on the other hand, maintains a consistent voltage, letting the current decrease as the battery fills up, which helps prevent overvoltage and ensures a full charge, but may also slow down the final stages of charging. A widely used strategy is the Constant Current-Constant Voltage (CC-CV) method, which starts with a high constant current and switches to constant voltage as the battery nears full capacity, balancing both speed and safety. More advanced techniques like Model Predictive Control (MPC) use battery models to predict the battery's behavior and adjust charging in real time, considering factors like temperature and state of charge (SOC) to optimize for speed and minimize degradation, though it's more computationally complex. Similarly, adaptive control strategies adjust the charging parameters based on real-time battery data, optimizing for factors like battery aging and varying conditions, which is key to ensuring safe and efficient charging over the battery's lifespan. The choice of controller often depends on the specific goals of the research, affecting implementation details, performance measures (such as charging time and temperature), and comparisons with other methods.

The unidirectional boost converter, illustrated in Fig. 1, plays a vital role in several DC rapid charging architectures for EVs by elevating the input voltage (V_a) to a higher level (V_o) appropriate for battery charging. This conversion is achieved using an inductor (L_1), a semiconductor switch (S_1), and a diode (D_o). When the switch is activated ('on' state), energy is accumulated within the inductor. Conversely, when the switch is deactivated ('off' state), the inductor releases this stored energy, combining with the input voltage to supply the output circuit through the diode, thus raising the voltage across the output capacitor (C_o) and the load. The term "unidirectional" signifies that power flows exclusively from the input to the output, making this converter ideal for applications requiring a boosted DC voltage without the need for regenerative braking or reverse power transmission. Its relative simplicity and efficient operation establish it as a foundational element in DC-DC conversion for electric vehicle charging systems.

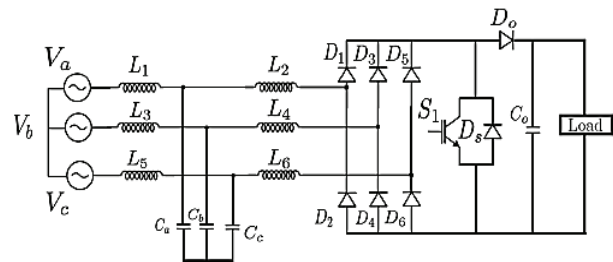


Fig. 1. Unidirectional boost converter

The Vienna Rectifier, a three-phase Pulse Width Modulation (PWM) rectifier, stands out for its ability to achieve high power factor and low harmonic distortion in AC-DC conversion. Unlike conventional diode rectifiers, the Vienna Rectifier employs controlled switching, typically using Insulated Gate Bipolar Transistors (IGBTs), to shape the input current waveform, making it nearly sinusoidal and in phase with the input voltage. This results in a high power factor, minimizing reactive power and improving overall system efficiency.

The 3-phase AC/DC buck-boost converter offers a versatile solution for power conversion, capable of both stepping down (buck) and stepping up (boost) the input AC voltage to a desired DC output level.

This type of converter typically employs a controlled rectification stage, often using PWM techniques, to convert the 3-phase AC input into a pulsating DC waveform. Following rectification, a DC-DC converter stage, often

based on a buck-boost topology, processes this pulsating DC to generate a regulated DC output. The switching action within the DC-DC stage allows for control over the output voltage magnitude, enabling it to be adjusted either higher or lower than the peak of the rectified AC voltage. This dual functionality makes the 3-phase AC/DC buck-boost converter suitable for applications where the input AC voltage may vary or where a specific DC output voltage is required regardless of the AC input level, finding use in areas like renewable energy systems, industrial drives, and battery charging applications.

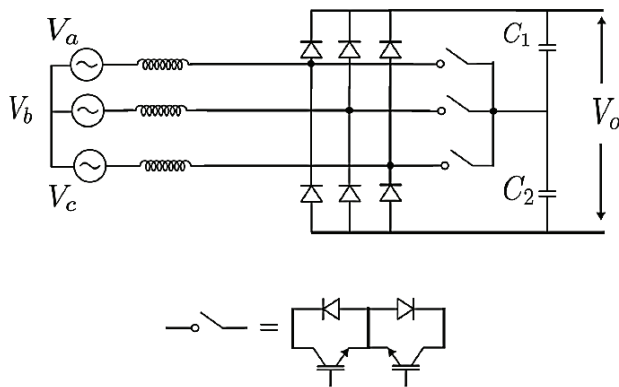


Fig. 2. Vienna Rectifier

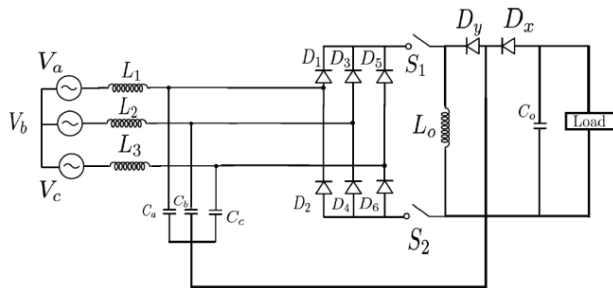


Fig. 3. 3-phase AC/DC buck-boost converter

The Simulation represents a DC fast charging system for electric vehicles (EVs), illustrating power flow and control strategies. The system starts with an AC grid input, which is processed through a rectifier and a front-end converter to obtain a regulated DC voltage. A DC-DC converter with galvanic isolation then steps down and regulates the voltage to match the EV battery's charging requirements. The model integrates a Field-Oriented Control (FOC) strategy via the mABC block for precise current and voltage control. The charging process is monitored through various scopes, tracking key parameters such as DC bus voltage, current, charging voltage, battery current, and state-of-charge (SOC). The DC-DC converter control circuit regulates the

gate pulses based on battery current feedback to ensure efficient and safe charging. Additionally, a powergui block enables harmonic analysis (THD analysis) for evaluating power quality. This simulation provides a comprehensive framework for studying fast-charging dynamics, power conversion efficiency, and grid interaction.

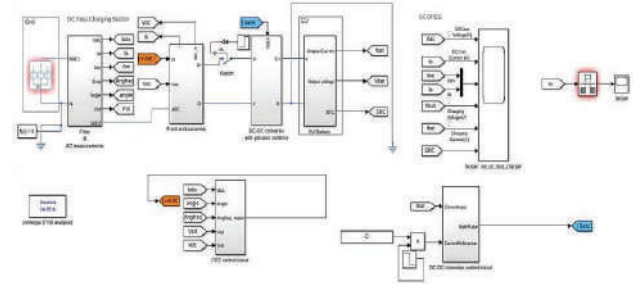


Fig. 4. Simulation for DC fast Charger

Filter & AC Measurements to filter the harmonics in the line current and measure the three-phase supply voltage and line current.

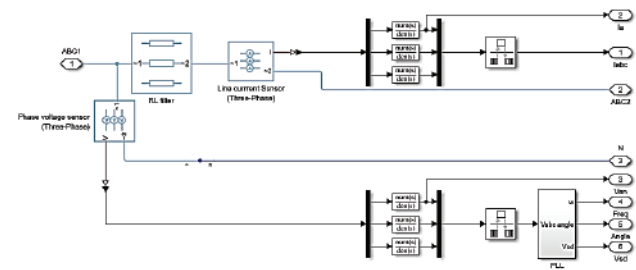


Fig. 5. Filters for DC fast Charger

Unity Power Factor (UPF) Front End Converter (FEC) to control output DC voltage at 800 V.

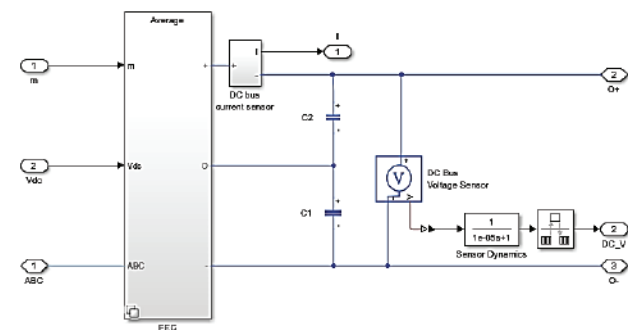


Fig. 6. UPF for DC fast Charger

The simulation results show how the DC fast charger is performing by analysing key electrical parameters like voltage, current, and frequency components. The graph

represents the frequency spectrum, with a big peak at a low frequency, indicating the main operating frequency of the system. The table below the graph provides details on harmonic distortion, including Total Harmonic Distortion (THD) and key harmonic frequencies (H1, H2 and H3). A high H1 value means most of the power is concentrated at the fundamental frequency, while the other harmonic values help assess system efficiency and power quality. This analysis is useful for improving charger performance, reducing energy losses, and ensuring the system operates smoothly without causing disturbances to the grid.

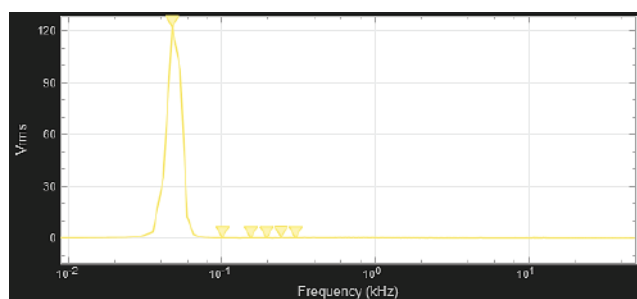


Fig. 7. Harmonics Frequency

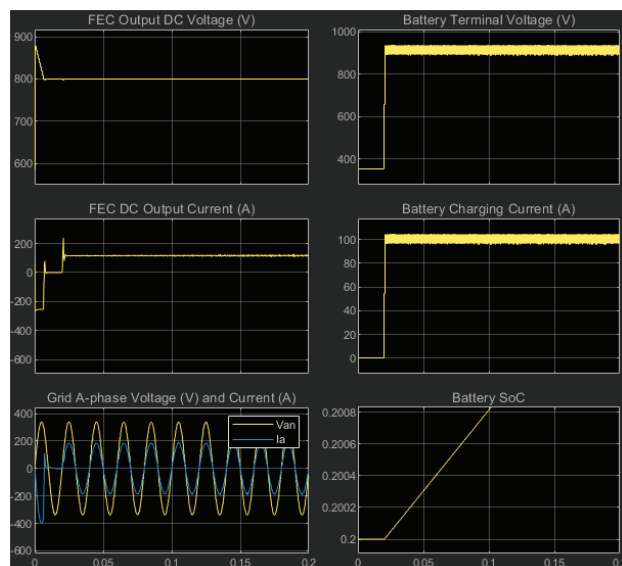


Fig. 8. Simulation results for DC fast Charger

RESULTS AND DISCUSSION

The simulation results provide a detailed look at how the DC fast charger operates, ensuring efficient and stable power delivery to an electric vehicle battery. The front-end converter (FEC) maintains a steady DC output voltage of around 900V, supplying the necessary power for the DC-DC converter. Initially, the output current experiences a

transient spike before stabilizing, which is typical as the system adjusts to the load demand. On the battery side, the terminal voltage quickly rises to the charging level, while the charging current holds steady at approximately 100A, ensuring a smooth and consistent energy transfer to the battery.

The grid input voltage and current waveforms display a typical sinusoidal pattern, indicating that the charger draws power efficiently from the grid without excessive distortion. The state of charge (SoC) of the battery steadily increases in a linear fashion, reflecting a well-regulated charging process. This smooth SoC curve suggests that the system prevents sudden surges or fluctuations, which is crucial for battery health and longevity.

Overall, the results confirm that the DC fast charger is performing as expected, with stable voltage regulation, controlled current flow, and efficient grid interaction. These insights are valuable for optimizing charger design, improving power efficiency, and minimizing any negative impact on the electrical grid.

CONCLUSION

DC fast charging significantly reduces EV charging time, making long-distance travel more convenient and accelerating adoption. However, frequent use can generate excess heat, leading to faster battery degradation and reduced lifespan if not properly managed. While it offers quick energy replenishment and smart grid integration, it also requires costly infrastructure and can strain the electrical grid. Advancements in battery technology, thermal management, and intelligent charging algorithms are essential to minimize these drawbacks. A balanced approach using fast charging when needed and slower charging for daily use can help maintain battery health while ensuring the convenience of rapid charging for EV users.

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Design and Development of IoT based SCADA System for Electrical Machine Lab, SBJITMR

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ABSTRACT

Real-time machine monitoring and control are essential for operational safety and efficiency in contemporary electrical engineering labs. The Supervisory Control and Data Acquisition (SCADA) system proposed in this project is IoT-enabled and designed specifically for an Electrical Machine Lab. By using IoT technology, the system makes it possible to remotely monitor and operate electrical motors. Important parts include sensors like the PZEM for electrical parameters sensing (voltage, current, and power), the DHT11 for temperature and humidity, and an infrared sensor for motor speed detection. For real-time data storage and accessibility, the Node MCU ESP8266 microcontroller uses Firebase to send the gathered data to the cloud. MIT App Inventor is used to create a smart phone android application that offers a user-friendly interface for real-time motor parameter monitoring, hence improving user interaction. In the laboratory setting at S B Jain Institute of Technology, Management and Research (SBJITMR), this IoT based SCADA system provides a scalable, economical, and robust solution that improves operational control, increases machine reliability, and guarantees safety.

KEYWORDS : *Data acquisition, IoT, NodeMCU, SCADA.*

INTRODUCTION

The elevation of supervisory control and data acquisition (SCADA) from IoT technology in the past few years has itself been a revolution in monitoring and controlling industries. As IoT technology integrates SCADA systems, there are improvements on the efficiency, reliability, and security of operations in industries. For instance, replacing conventional Remote Terminal Units (RTUs) with IoT devices enables real-time data collection and wireless transmission, saving on maintenance hours and adding flexibility [1]. Additionally, IoT-based SCADA systems are useful for monitoring and controlling of solar photovoltaic systems to optimize energy generation and minimize idle time [2]. Examples of parameter monitoring, which remain accurate and within thresholds, include temperature,

voltage, current in the line, and there can easily happen a predictive maintenance schedule, allowing reduction of equipment failures in the industrialized set up [3]. Apart from that, these systems are capable of making forecasts on electricity generation concerning hydropower stations by time series analysis for the appropriate management of power grids [4]-[5]. IoT-based SCADA systems development and design also put much emphasis on wireless communication and internet protocol application for the safe reliable functioning of such SCADA systems, as such systems can be termed intelligent or in-they can avoid interruption and/or interference of communication even when critical infrastructure is in emergency operation situations [6]. The studies reveal that there is incredible potential in future IoT-based SCADAs on how they will transform the monitoring and control of industries in all

aspects guaranteeing higher efficiency, reliability, and security in all possible applications [7]. This paved way for future smart, more adaptive, and connected industrial systems that adopted IoT technologies.

METHODOLOGY

The entire work is developed in several stages-key ones involve system architecture design, component selection and wiring, data collection and transmission, mobile app development, relay control logic and testing. Each stage describes the integration of sensors, microcontrollers and communication protocols, which can be remotely monitored and controlled in real time using Firebase Cloud and an individual mobile application.

System Architecture Design

The architecture of the system revolves around NodeMCU ESP8266 which is mainly the controller, interfacing both sensors and an Arduino Nano on it so environment data, electrical and rotational data will be gathered. The NodeMCU connects to Wi-Fi for data transmission and communicates with the Arduino Nano to retrieve speed data via an IR sensor. Additional sensors such as the PZEM-004T provide voltage, current and power readings, while the DHT11 sensor monitors temperature and humidity. Two relays serve as start and stop control functions, remotely controlled through the mobile app. This design allows for centralized data processing and remote control of the connected devices.

Component Selection and Wiring

The choice of components was guided by compatibility, low power requirements and suitability for SCADA applications. The Node MCU, with its built-in Wi-Fi module, serves as the central hub and communicates with the Arduino Nano through Serial communication for speed measurement. Sensors such as the PZEM-004T and DHT11 are connected directly to the NodeMCU, providing power metrics and environmental data, respectively. The relays are connected to the Node MCU's GPIO pins, enabling remote control functionality through the app. This arrangement ensures efficient data flow and ease of access to all system components.

Data Collection and Transmission

Essential parameters such as voltage, current, power, temperature, and humidity was captured and aggregated by the Node MCU from the PZEM-004T and DHT11 sensors. Meanwhile, an IR sensor connected to the

Arduino Nano measured the RPM that was processed by the Arduino Nano and then sent to the NodeMCU through Serial communication. The NodeMCU is responsible for compiling all data and uploading it to Firebase Cloud Platform using unique labels against each parameter to allow retrieval and display in the app. The system was designed for continuous real-time data acquisition and centralization in Firebase.

Mobile App Development with MIT App Inventor

Using MIT App Inventor, a mobile application was designed to provide access to real-time data and control over the system functions. The application shows data and has buttons for start-and-stop controls. Integration of Firebase allows for the real-time update of data in the app, while control buttons communicate with Firebase to update the relay states.

Relay Control Logic and Functionality

Relay control logic is one of the important parts of the system. Relay control logic is considered an important feature of this system. Two relay contacts are involved: an normally open (NO) relay contact for the start operation and an normally closed (NC) relay contact for the stop operation. The application has been developed using the MIT App Inventor mobile application and is capable of triggering these relays. When activated, the start relay contact will stay in the energized state for about two seconds and then return to its original state. Similarly, the stop relay returns to its original state after two seconds when activated through the app. Both these relay operations act as push buttons and integrated with the motor control logic for motor control through local and remote operation.

Testing and Troubleshooting

In the proposed methodology, the system was undergone through connectivity, accuracy in data, and relay tests. The Wi-Fi connectivity became the airline of noninterruptability between NodeMCU and Firebase for receiving, sending, and subsequently verifying the whole data process. To complete achieving its test, serial communication was performed between the Arduino Nano and NodeMCU to verify accurate the RPM data transfer.

Firebase's capability of transmitting real-time data

was verified through the comparison of readings from the sensors and their corresponding relay states as compared to the physical actual outputs of such devices as displayed in the app. Usability test results that guarantee the proper

time and accurate content that the application displays and the data instantly syncing upon updates to Firebase.

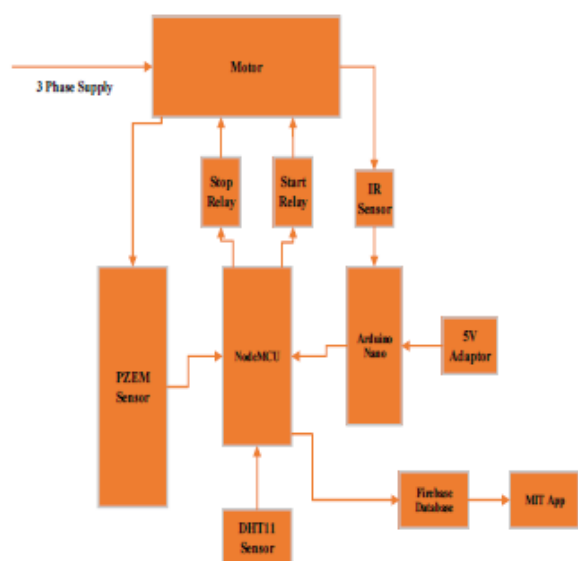


Fig. 1 Block diagram of IoT based SCADA system for Laboratory AC Induction motor

Block diagram

As illustrated in Figure 2.1, central control of the system revolves around the Arduino Nano and NodeMCU microcontroller unit (MCU) that communicates with the temperature sensor, PZEM sensor, relays and devices and Internet. The sensors detect various parameters in real-time which is captured by the microcontroller, recorded and stored in the Firebase cloud.

SYSTEM ARCHITECTURE

Node MCU ESP8266

Node MCU ESP8266 used in the project is an open source, low cost development board, which is fundamentally based upon ESP8266 Wi-Fi Microcontroller. It has inbuilt Wi-Fi, multiple GPIO pins for connecting various sensors and devices, and can be programmed using Arduino IDE or Lua and is best suited for this project because of its various features.

DHT 11 Temperature & Humidity Sensors

The DHT11 sensor used in the project is an inexpensive, widely-utilized digital device intended for temperature and humidity readings. It has thermistor-based temperature sensing and a capacitive humidity sensor for accurate measurements from 0 to 50 °C in temperature and from 20 to 90% relative humidity [8]-[9].

PZEM Sensor

The PZEM-004T AC communication module used in the project is a high-precision sensor for AC parameters monitoring device, measuring the voltage, current, active power, frequency, power factor and active energy. The voltage measurement range is between 80-260V whereas the current measuring range is 0-100A. For active power, 0-23kW power is measured whereas; power factor from 0.00-1.00 and frequency from 45-65Hz is tracked. The active energy it records is up to 9999.99kWh. This makes it a very flexible and reliable sensor over a longer period for power monitoring [10].

IR Sensor

Infrared sensor (IR) used in the project uses infrared rays for detecting objects or measuring movement. An emitter sends infrared rays and a detector confirms reception of the reflected rays from the object. During monitoring of motors, an IR sensor measures the motor speed by sensing the rotation which is expressed in RPM (revolutions per minute).

Arduino Nano

The Arduino Nano used in the project is a tiny and compact microcontroller board that is based on the ATmega328P microcontroller chip. It has most of the advantages compared to large Arduino boards such as 14 digital input/output pins, 8 analog inputs, and a USB connection for programming in a compact size. It was used to detect speed from the IR sensor and send it to NodeMCU for Cloud upload.

Firestore Real time Database

The Firestore Realtime Database used in the project is a cloud-based NoSQL database that allows real-time data syncing across devices. It's part of Google's Firestore platform, designed to help developers build and manage apps, especially those requiring real-time data.

MIT App Inventor

MIT App Inventor an easy-to-use platform was utilized for this project to create mobile app without advanced coding. It uses a drag-and-drop interface for building apps, making it convenient for fast app development.

DESIGN IMPLEMENTATION

The process involved the integration of several hardware parts like sensors, microcontrollers, and relays to establish connectivity with a cloud for live and future data storage.

In such areas, system efficiency improvement is possible; moreover, the users can control the system remotely. Key for this system is the NodeMCU ESP8266, which is a microcontroller with Wi-Fi being the major line of communication between the sensors, Arduino Nano, and Firebase database. NodeMCU collects the data from the connected sensors, and the data is sent to the Firebase cloud platform in real time. The ESP8266 basically enables the whole system to transfer and receive data through the internet instead of wires through which a user can monitor the whole system anywhere in the world using a mobile application.

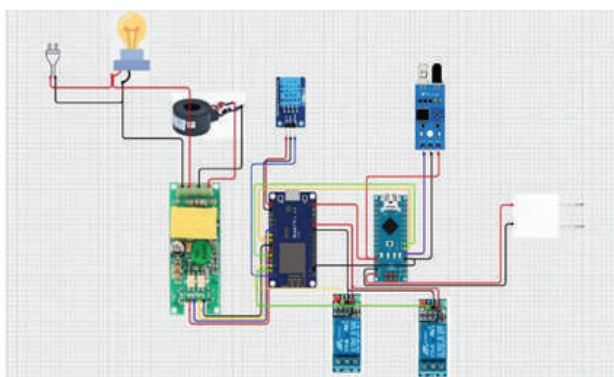


Fig. 2 Circuit Diagram of the project

The system uses two key sensors: the PZEM- 004T and the DHT11. The PZEM-004T sensor monitors electrical parameters like voltage, current, power and energy consumption, offering insights into the system's energy efficiency. The DHT11 sensor tracks environmental conditions, such as temperature and humidity, which are important for monitoring the system's operating environment. These sensors are continuously sending real-time data to NodeMCU for processing and storing it. In addition, an IR sensor is interfaced with the Arduino Nano into the system to measure the speed of the system. The Arduino collects the speed data and then transmits it to NodeMCU. With this, the system can gather vast amounts of environmental and electrical data. But on top of those, it can also measure the ones such performance metrics like speed in real time. NodeMCU forwards the speed data together with other data from sensors to the Firebase database. Firebase serves as a central storage from which one can access the data and the availability of such data for remote monitoring.

The app developed in MIT App Inventor has an interface that connects and operates in tandem with Firebase to display data captured in the database of Firebase on

Android devices. Some data including speed, voltage, current, temperature, and humidity are retrieved in real-time and made available for viewing. This can track and monitor the parameters on mobile phones for easy access to performance data from the system. The system is a mobile app that serves as a user interface created for graphical data view and interaction of users with the system remotely. For added control, the application also has two relays that work like pushbuttons for starting and stopping. These relays can be enabled from a distance through a mobile app. When the user presses the start button in the app, the relay powers on the system and when the stop button is pressed, the relay cuts off power. This makes the system quite flexible, owing to its convenience; thus giving the users room to use the system anywhere without being physically present.

HARDWARE IMPLEMENTATION

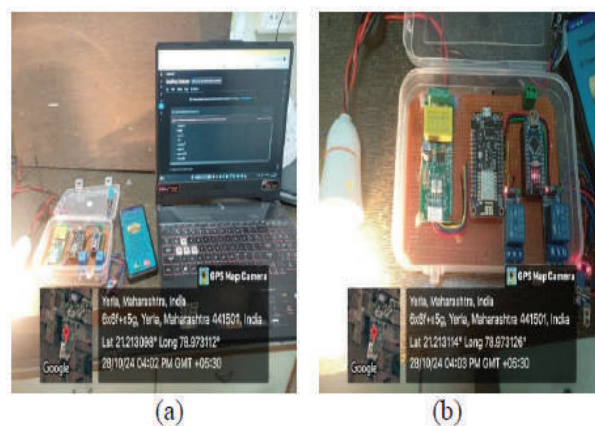


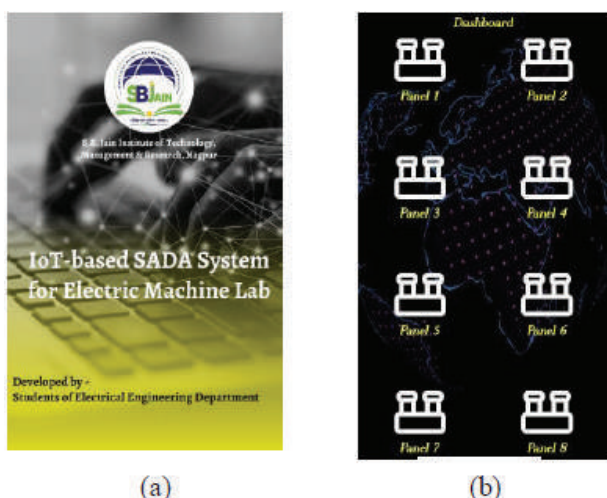
Fig. 3 (a)(b)Hardware implementation of the Project, (c) implementation of model in Machine Lab

The pin connection of the micro-controllers and various sensors are shown in below table 1.

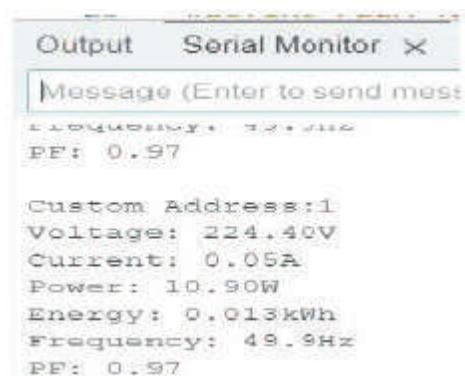
Table 1 Pin connections of NodeMCU, Arduino, sensors and relays

SrNo.	Component	Microcontroller	Component Pin	Microcontroller Pin
1	PZEM-004T	NodeMCU ESP8266	RX	D7
			TX	D6
2	DHT 11	NodeMCU ESP8266	DATA	D0
3	Stop Relay	NodeMCU ESP8266	IN	D2
4	Start Relay	NodeMCU ESP8266	IN	D1
5	IR Sensor	Arduino NANO	OUT	D2
6	AC Adapter	Arduino NANO	5V	VIN
			GND	GND
8	Arduino Nano	NodeMCU	5V	Vin
			GND	GND
			D3	D5
			D4	D4

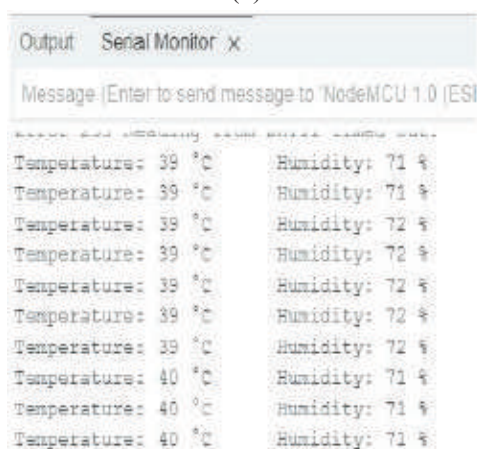
RESULTS

**Fig. 4.** (a) Initial display screen on APP (b) Panel display screen on APP

(a)



(b)



(c)

Fig. 5 (a) DHT11 sensor readings (b) PZEM sensor readings (c) IR sensor readings on serial monitor

The design and development of the IoT-based SCADA system in the Electrical Machine Lab successfully achieved its goal of real-time monitoring of motor performance. Using sensors like the DHT11 for temperature and humidity, PZEM for electrical parameters (voltage, current and power) and an IR sensor for motor speed, the system accurately collected data from the motor. This data was transmitted wirelessly to Firebase, a cloud-based database, via NodeMCU ESP8266, ensuring real-time storage and access.

Created by using MIT App inventor, a user-friendly mobile application has a virtual interface that permits users to monitor these parameters remotely. Thus, the overall flexibility and efficiency of the system increased. Users could access real-time data, historical trends, and alerts regarding abnormal conditions. Thus, supervision manually was required, in part, and improved efficiency within the laboratory as a whole. The system has shown

well for data collection, real-time data transmission, and access from a distance. Uniqueness is that the system allows expanding the number of motors or adding other sensors, hence making it a scalable system.

The SCADA system based on an IOT has improved the operation of the laboratories by automatically acquiring data and thereby facilitating remote monitoring, giving a clear pointer towards efficiency and safety enhancement in environments with electrical machines.

CONCLUSION

The project “Design and Development of IoT- based SCADA System for Electrical Machine Lab” demonstrates a real-time monitoring, control and data acquisition capability in traditional SCADA through IoT technology. The total tracking of temperature, humidity, electrical parameters and motor speed with the help of sensors like DHT11, PZEM and IR sensor improves operational efficiency and safety. NodeMCU ESP8266 is used for wireless transmission of data to Firebase; hence it is stored seamlessly in the cloud in a way that it can be accessed anytime. Furthermore, the mobile app allows the user to access an intuitive interface for monitoring and control. These features may improve the overall safety and functionality of the lab. This project highlights the potential of IoT in modernizing industrial monitoring and control, offering a scalable, efficient and user-friendly solution for electrical machine labs. It serves as a practical model for future IoT applications in smart automation and remote system management.

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Design and Development of an IoT Based Distribution Transformer Oil Monitoring For Detecting Oil Pilferage

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ABSTRACT

Distribution transformers are important additives of electricity networks, yet their efficiency is regularly undermined by means of the theft of transformer oil. This has worrying consequences for the economy. Loss, environmental hazards and conservation issues for monitoring oil levels are often fail. Stumbling and falling directly into a theft makes this entire worse demanding situation. To solve this problem, we have design a system using IoT which display video continuously selling both grades and high quality transformer oil. The machine employs sensors to accumulate information on oil stages and sends this information wirelessly to a crucial tracking platform. A cloud-based analysis detects anomalies, including unexpected drops in oil tiers, which may additionally signal theft. By delivering timely indicators, this gadget seeks to lessen financial losses and environmental threats even as for the smooth operation of distribution transformers. The incorporation of IoT era gives a sensible and effective way of defensive transformer oil and maintaining the stability of power distribution networks.

KEYWORDS : *IoT, Sensors, Transformer oil theft, Real-time monitoring, Cloud analytics.*

INTRODUCTION

Distribution transformers play an important role in the electrical system. The role of reducing the voltage level to meet user needs however, these transformers are economic losses for utility companies. Safety and environmental hazards [4, 1] are not that common. How to test the oil level yourself is not only complicated, but it's still prone to oil theft, in addition to this significant not powerful enough to detect theft quickly enough, which it can. To solve the problem of Mechanical damage and power outage, IoT-enabled delivery converter proposes an oil tracking system has introduced. Advanced sensors and for further wireless connectivity check important parameters such as oil level and temperature. Superiority the collected data is sent to central analysis. Facilities that have any abnormalities, such as sudden oil leaks the level

is automatically identified as a potential theft. Such an approach allows for faster detection and action. traditional methods [2]. By facilitating remote monitoring and early detection of abnormalities, IoT- based systems not only improve the efficiency and reliability of electricity distribution networks helps prevent damage from oil theft but also lowers maintenance costs and prolongs the lifespan of Distribution Transformers Integrating the IoT era into the power system is a great development in solving the problem of oil theft with stable power delivery for buyers. IoT-based complete Distribution Transformer Oil Inspection initiative addresses the urgent problem of oil theft which threatens the reliability of the equipment. Traditional inspection techniques require a lot of effort. Prone to errors and often these things fail to sneak in timely fashion. This initiative aims to create some IoT based devices for real time monitoring of transformer oil

range, temperature, stress, different important parameters and the distance thrown. [3].

METHODOLOGY

There are several important steps and additives in how to monitor transformer oil in an IoT-based system to detect oil theft. First, sensors are strategically connected to power transmission transformers to continuously monitor parameters. Factors such as oil phase, temperature, stress, and dielectric strength. These sensors are connected to a microcontroller or gate device. It collects real-time data and creates strategies. The collected data is then sent to a key server or cloud platform through an internet connection. Using IoT protocols with MQTT or HTTP [1], algorithms are defined to capture patterns that identify routine tasks and provide recommendations on anomalies including theft or leakage of the fuel capacity. Additionally, the gadget has security measures to protect you from unauthorized access. Overall, this technique integrates effectively in building the IoT. The use of fact-based analysis and security measures can facilitate the early detection and prevention of oil theft in distribution transformers. It facilitates the reduction of losses and maintains reliable electricity delivery.

PROPOSED SOLUTION

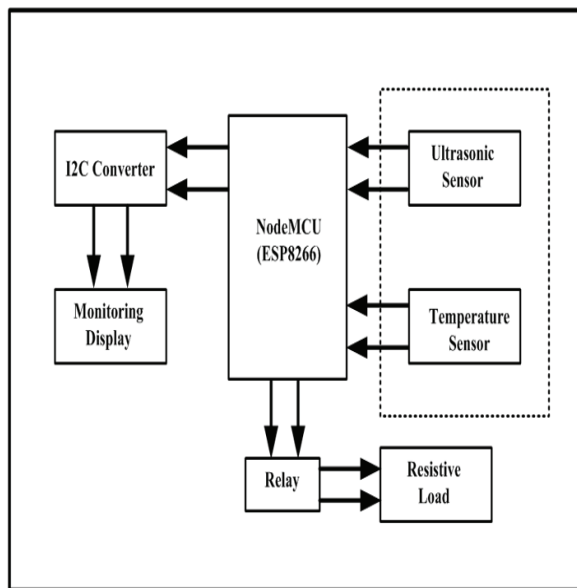


Fig. 1 Block Diagram of Proposed Methodology

Our solutions for oil inspection in distribution transformers designed to efficiently detect oil using IoT

technology which will minimize losses by protecting essential infrastructure with strategically placing sensors over the distribution. Electrical transformers that we can continuously monitor significantly parameters such as oil level, temperature, pressure, and flow Value [2, 3]. This real-time data is transmitted securely to a central location. Cloud Stage where advanced algorithms analyze symbols. When the problem such as Oil theft or unusual activity is detected, the notification system provides information to the relevant parties. It will immediately help to work faster. Our solution integrates and provides smooth intuition with the existing system. Interface for detailed visualization and analysis of historical trends. The strong security measures including regular encryption and authentication of regulators Attached. In summary, our IoT-based approach Monitoring transformer oil improves operational efficiency and protect against potential theft threats.

SIMULATION MODEL

Proteus simulation software is a powerful tool commonly used in electronic design automation (EDA). It provides a complete environment for designing, simulating, and testing electronic circuits and systems [4]. Users can cover both analog and digital circuits. Create a plan for different situations and model their behavior. With support for mixed- mode simulation, Proteus is able to design systems in which analog and digital components work together seamlessly [5]. The software's virtual prototyping capabilities help designers recognize and resolve design issues early. Save time during development and stay protected. Proteus also provides a library of a wide variety of microcontroller models, making it easy to develop and test embedded systems [6]. Real- time simulation capabilities allow users to interact with their designs as if they were physically connected. This is especially useful for testing control systems. This software has tools for signal analysis. It allows users to visualize and evaluate parameters such as voltage, current, frequency and phase with graphical operation options such as oscilloscopes and logic analyzers. Users can effectively evaluate the simulation results. Proteus also helps simplify the entire electronic product development process by integrating circuit design and simulation into the PCB layout design. Briefly, Proteus simulation software allows Engineers and designers have the tools needed to create reliable and efficient electronic designs with confidence.

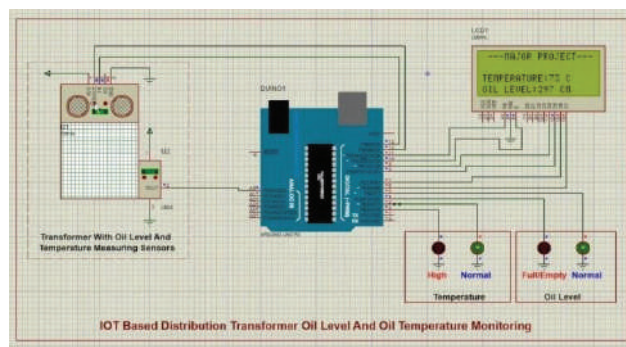


Fig. 2 Simulation Model by using Arduino Uno

Table. 1. Components used in Prototype

Sr. No.	Tools	Description
1	Transformer	240/12 V, 5 Amp
2	Temperature Sensor	LM 35
3	Relay	5V Single Channel
4	ARDUINO UNO	ATmega 328P chip
5	Display	An alphanumeric liquid crystal display (LCD) display 16 characters in a row, for a total of 32 characters
6	Ultrasonic Sensor	Double Transducer, 40KHz, 6m range
7	Node MCU	ESP8266

Transformer: A transformer is a tool that transfers electric power between two or extra circuits the usage of the transmission of electromagnetic waves. The coils are referred to as primary and secondary windings. They are normally wrapped round a shared core manufactured from ferromagnetic cloth. Power transformers are extensively used to step up or step down voltage tiers in electrical distribution structures [7].

Temperature Sensor: A temperature sensor is a digital device that measures environmental temperature and converts the detected information into an electronic signal that records or indicates changes in temperature.

Relay: A relay is an electrically operated switch. It opens and closes the circuit based on indicators from an external source. When the relay gets a sign, it activates and rancid to send a signal to different gadgets.

ARDUINO UNO: Arduino Uno is a well-known microcontroller board based totally on the ATmega328P chip. It is one of the most extensively used boards in the

Arduino family, recognized for its simplicity. Versatile and easy to use, Mon Load: The light bulb have to act as a load for the electric circuit. When linked to the energy supply Lamps use electrical power to supply mild and warmth. The motor draws modern-day and emits mild from the circuit. In addition to electric gadget and different system of the heater Increase the general performance of the gadget.

Display: A 16x2 display typically refers to an alphanumeric liquid crystal display (LCD) that can display 16 characters in a row, for a total of 32 characters. These displays are commonly found in electronic devices such as digital clocks and small appliances, as they offer a straightforward and easy-to-read interface for presenting text or simple graphics.

ULTRASONIC SENSOR: An ultrasonic sensor is a device that uses sound frequencies to detect the presence and measure distance from distant objects.

DESIGN & IMPLEMENTATION

- Requirements analysis:** Understand the requirements and purpose of an oil monitoring system. Specify the main parameters to be checked. This includes fuel levels, temperature, pressure and any unusual activity that may indicate theft
- Sensor selection:** Choose the right sensors to monitor oil level, temperature, and pressure. Choose sensors that provide IoT connectivity so that data can be transmitted wirelessly [7]. Sensor selection, Choose an IoT platform to collect, store, and analyze data and options like Blynk IoT, AWS IoT, Azure IoT, or Google Cloud IoT as they offer powerful scalability, security, and data analytics features.
- Choosing an IoT platform:** Choose an IoT platform for data collection, storage, and analysis. Consider platforms like Blynk IoT, AWS IoT, Azure IoT, or Google Cloud IoT, which provide scalability, security, and data analytics.
- Hardware settings:** Installed sensors on distributed transmitters to monitor oil level, temperature, and pressure. Connect these sensors to a microcontroller or IoT module to collect and transmit data.
- Data communication:** Established communication protocols (such as MQTT or HTTP) to send sensor data to the IoT platform, ensuring that data transmission is secure and reliable. This is especially

true when dealing with sensitive data such as oil level and temperature.

6. **Data storage and analysis:** Save sensor data in a database or cloud storage for further analysis. It uses algorithms to analyze data to identify anomalies or unusual patterns that may indicate oil theft. Create alerts or notifications to inform stakeholders of suspicious activity in real time.
 7. **Visualization and Reporting:** Create a dashboard or user interface to display both real-time and historical data. Offer customizable reports and insights to aid in decision-making and monitoring. [8]
 8. **Integration and testing:** Connect all system components and perform thorough testing to ensure everything works as intended. Evaluate the system under various conditions and situations. To confirm the effectiveness of the oil theft test.
 9. **Use and maintenance:** Deploy an IoT-based monitoring system at a distribution transformer site. Establish maintenance procedures for routine inspection, calibration, and troubleshooting of sensors and equipment [12].
 10. **Compliance with regulations:** Ensure compliance with standards and guidelines related to oil inspections and safety. Obtain necessary approvals and certifications prior to use [1, 4, 11].
 11. **Training and support:** Provide training to employees responsible for operating and maintaining the tracking system. [1] Provide ongoing technical support and assistance to resolve any issues or concerns.
4. **Detection according to criteria:** Set criteria for key parameters based on historical data and operating assumptions. Triggers alerts or alarms when sensor readings exceed a preset threshold. This indicates possible theft or abnormal conditions.
 5. **Machine Learning Models:** Train machine learning models to classify sensor data into normal and anomalous instances. Supervised learning algorithms such as support vector machines (SVM), decision trees, or neural networks can be used for classification. [2]
 6. **Real-time Monitoring and Alerting:** Implement real-time monitoring capabilities to continuously analyze incoming sensor data. Set up alerting mechanisms to notify stakeholders immediately when suspicious activity is detected. Alerts can be sent via email, SMS, or integrated into monitoring dashboards for quick response.
 7. **Historical Analysis and Reporting:** Conduct retrospective analysis of historical sensor data to identify past instances of oil pilferage or unauthorized access. Generate reports and visualizations to summarize key findings and trends over time.
 8. **Integration with IoT Platform:** Integrate data analysis algorithms into the IoT platform for seamless processing of sensor data

FLOW CHART OF DATA ANALYSIS, RESULT & DISCUSSION

1. **Data pre-processing:** Cleans sensor data by eliminating noise, outliers, and missing values. Convert sensor readings to meaningful metric units such as fuel level, temperature, and pressure. Normalize or scale data to ensure that sensors and time intervals are accurate will be consistent [13].
2. **Feature separation:** Extract relevant features from sensor data that may indicate theft or unusual behavior. Features include deviations from normal operating conditions. Sudden changes in oil level or temperature and unusual patterns in sensor readings.
3. **Anomaly detection algorithm:** Uses anomaly

detection algorithms to identify deviations from expected behavior. Statistical analysis machine learning and other techniques [14].

4. **Detection according to criteria:** Set criteria for key parameters based on historical data and operating assumptions. Triggers alerts or alarms when sensor readings exceed a preset threshold. This indicates possible theft or abnormal conditions.
5. **Machine Learning Models:** Train machine learning models to classify sensor data into normal and anomalous instances. Supervised learning algorithms such as support vector machines (SVM), decision trees, or neural networks can be used for classification. [2]
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RESULTS

The IoT-based distribution transformer oil inspection project shown in fig. 3 aims to detect oil theft and increase operational efficiency. By installing IoT sensors, the systems allows real-time monitoring of oil levels and other important parameters, detecting abnormal variations and reduce oil theft. The system can quickly act as an early warning preventing damage to the transformer and reducing downtime. Continuous data collection facilitates proactive maintenance planning and improves maintenance decisions and resource allocation shown in fig. 4. Real-time monitoring improves the reliability of transformer operation.

This reduces fuel theft and reduces downtime. This results in significant cost savings for suppliers. The program also allows efficient tracking of remote and inaccessible

transformers. In Fig. 5, demonstrated the potential of IoT to solve traditional utility challenges.



Fig. 3 Working Model Connected with Node MCU

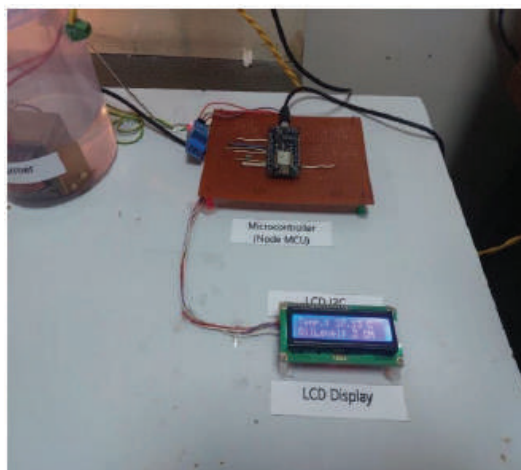


Fig. 4 Display of Output



Fig. 5 Model with connected Resistive Load

Data analysis and provides a predictive view of savings and proper allocation of resources for long- term economic growth. Overall, the project represents a major advance in smart utility management.

Demonstrated the effectiveness of IoT technology in enhancing distribution transformer management, offering a scalable solution for utilities to improve asset protection and operational performance.

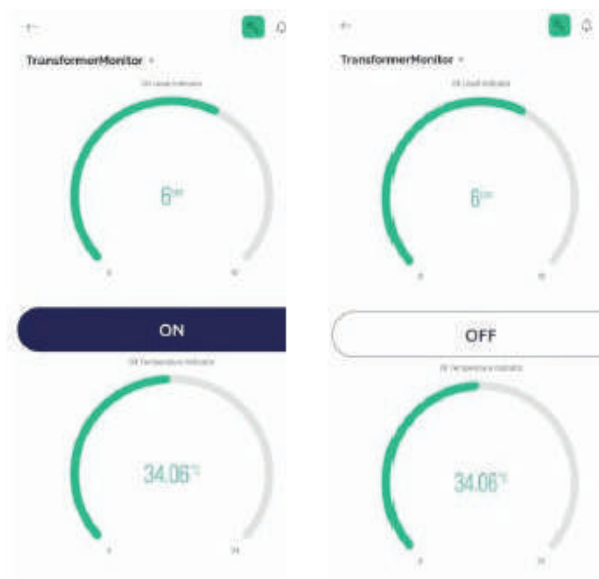


Fig. 6 Temperature Monitor

CONCLUSION

The use of an IoT-based distribution transformer oil monitoring system provides a proactive and efficient solution for detecting oil theft in the power distribution network. Using IoT sensors, real-time data analysis and remote monitoring various utilities. It can significantly improve the security and integrity of the infrastructure, in addition to facilitating faster detection and faster intervention to reduce losses and reliable operation of distribution transformers. It benefits a cost savings for better security compliance and environmental protection. Underscoring the value of IoT-based monitoring for utilities and society as technology continues to advance and energize Integrating IoT solutions into infrastructure is increasingly important to maintaining system reliability, performance, and sustainability. Therefore, investing in IoT-based monitoring to detect oil theft is not only a strategic decision for utilities but it is also an important step in increasing energy flexibility in distribution system amidst emerging challenges.

FUTURE SCOPE

The future scope of IoT-based distribution transformer oil monitoring for oil theft detection is promising along with several potential advances.

- Improvement analysis
- Integration with other systems
- Predictive maintenance
- Remote diagnosis and control
- Edge computing
- Energy Harvesting Sensors
- Standardization and Interoperability.

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Intelligent Transformer Control System for Efficient Power Distribution in Low Voltage Networks

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ABSTRACT

The growing need for efficient and dependable power distribution systems has brought attention to the shortcomings of traditional setups, especially under fluctuating load conditions. This paper introduces an intelligent transformer control system aimed at optimizing power distribution in low voltage networks. The system combines a primary and auxiliary transformer, an ACS712 current sensor, and an Arduino microcontroller to dynamically switch between transformers based on real-time load data. It guarantees optimized power distribution, improved efficiency, and prevention of transformer overloads. An LCD display enables real-time monitoring, allowing for continuous oversight and adjustments in power distribution. Safety features, including adequate insulation and protective devices, are included to ensure the system's reliability. The proposed system shows notable advancements in energy management for both residential and industrial applications, tackling the inefficiencies and reliability challenges found in traditional power distribution systems.

KEYWORDS : *Transformer control, Power distribution, Arduino, ACS712, Real-time monitoring.*

INTRODUCTION

The growing demand for efficient and reliable power distribution systems has exposed the limitations of traditional systems, which often struggle to perform optimally under varying load conditions [1]. This paper addresses these challenges by proposing an intelligent transformer control system that dynamically manages power distribution in low-voltage networks. The system leverages real-time data and automated switching to enhance the overall performance and reliability of power distribution networks.

The demand for effective power management solutions has become increasingly important due to the rapid growth in both residential and industrial energy consumption. Traditional power grids often struggle with inefficiencies, leading to wasted energy, higher operational costs, and added strain on transformers [2]. The proposed system offers a fresh approach to addressing these issues by

incorporating advanced control mechanisms that adjust transformer operations in real-time based on changing load conditions. By utilizing real-time data collection and analysis, the system can effectively balance power distribution, enhancing energy efficiency and prolonging system life [3]. Additionally, this research aims to optimize transformer usage to extend their lifespan, lower maintenance expenses, and maintain a reliable power supply [4]. By automatically identifying load changes and making accurate switching decisions, the system helps prevent transformer failures and reduces power interruptions. This feature is particularly advantageous in areas where power demand fluctuates significantly throughout the day, requiring a strong and adaptable power distribution system [5].

The main goal of this research is to create a smart transformer control system that enhances power distribution, boosts energy efficiency, and avoids transformer overloads. This

system combines a primary and auxiliary transformer, an ACS712 current sensor, and an Arduino microcontroller to meet these objectives. It features real-time monitoring via an LCD display, allowing for ongoing oversight and adjustments in power distribution. Furthermore, the system is designed to be affordable and scalable, making it ideal for both small and large power distribution networks.

LITERATURE REVIEW

Several studies have explored the integration of advanced technologies in power distribution systems. Fernando et al. (2017) proposed the use of Solid State Transformers (SSTs) in parallel with conventional transformers to enhance efficiency and reliability [1]. SSTs improve dynamic voltage regulation, power flow control, and efficiency, making them a promising alternative to traditional transformer-based systems. However, their high cost and complexity limit widespread implementation in low-voltage networks.

Similarly, Alcalá et al. (2011) investigated the use of Back-to-Back (BTB) power converters to balance transformer loads in low voltage networks [2]. The study highlighted the potential of BTB converters in mitigating transformer overloads, stabilizing voltage levels, and reducing power losses. Despite their advantages, these systems require sophisticated control mechanisms and expensive hardware components.

Xu et al. (2017) examined demand response strategies to manage peak loads in distribution networks [3]. While these approaches are effective at reducing peak demand, they often require advanced predictive algorithms and consumer participation, limiting their practical implementation in traditional distribution systems.

Chakraborty (2017) introduced the concept of autonomous power distribution using smart transformers equipped with computational intelligence [4]. The study emphasized the role of self-regulating transformers in maintaining grid stability, improving fault tolerance, and integrating renewable energy sources. While this concept is promising, its reliance on complex algorithms and real-time data analytics presents significant implementation challenges.

Our research builds on these foundations by introducing a cost-effective and scalable solution that utilizes commonly available components like the Arduino microcontroller and ACS712 current sensor. In contrast to SSTs and BTB converters, our method employs a straightforward load-

driven switching mechanism to dynamically balance transformer usage. This approach leads to better power efficiency, lower operational costs, and greater system reliability without the need for complex predictive models or expensive infrastructure. By incorporating real-time monitoring and automated switching, our proposed system offers a practical and efficient way to manage power distribution in low voltage networks. This research seeks to connect theoretical advancements with practical application by providing a simple yet effective alternative to traditional power distribution management techniques.

Points from Key References

Reference	Key Contributions
Fernando et al. (2017) [1]	Introduced Solid State Transformers (SSTs) to improve voltage regulation and efficiency in power distribution.
Alcalá et al. (2011) [2]	Explored Back-to-Back (BTB) power converters for balancing transformer loads in low-voltage networks.
Chakraborty (2017) [4]	Investigated autonomous smart transformers with computational intelligence for grid stability.
Alepuz et al. (2013) [5]	Proposed SST-based solutions with low-voltage ride-through capabilities and unbalance management.
Mohamed et al. (2013) [6]	Addressed transformer overload alleviation using intelligent control strategies.

METHODOLOGY

Low voltage distribution transformers encounter several challenges, including overloading, underutilization, and unbalanced loading, all of which can affect their efficiency and reliability. Overloading can lead to overheating and potential failures, while underutilization results in wasted energy. Additionally, unbalanced loading can cause voltage fluctuations and further losses. To tackle these problems, this paper explores the use of intelligent load management systems that incorporate real-time monitoring and adaptive control. IoT-based smart transformer control can adjust load distribution dynamically, enhancing both efficiency and performance. The smart transformer control system effectively manages power distribution by adjusting transformer operations based on real-time load conditions. It starts with the activation of key components, such as the Arduino and relays, with the main transformer powered on first. The system keeps an eye on load levels using the ACS712 sensor, showing real-time data on an LCD screen. If the load stays below a set threshold, only the main

transformer runs; if it goes over, the auxiliary transformer kicks in to avoid overload. This constant monitoring allows the system to adapt smoothly to load changes, ensuring efficient energy distribution. A controlled delay helps optimize the system's responsiveness while preventing overload. This ongoing process boosts system reliability, enhances power usage, and guarantees smooth operation under different conditions.

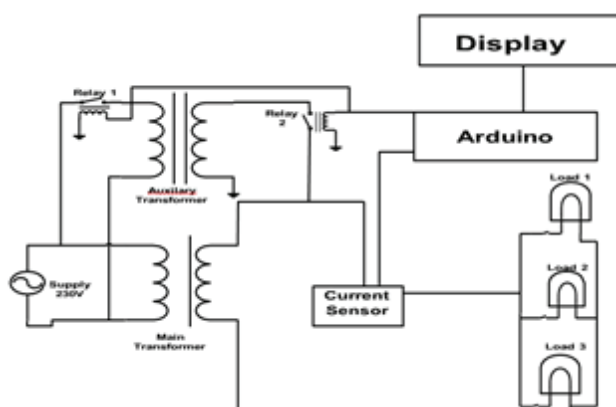


Fig. 1: Block Diagram

Specifications

Transformers: Two transformers, a primary and an auxiliary, each rated at 40VA and 3.3A, are utilized for power distribution management. The primary transformer functions under normal load conditions, while the auxiliary transformer kicks in when the load surpasses a set threshold of 3A (90% of one transformer's rating). **ACS712 Current Sensor:** This sensor tracks the load current in real-time and relays the information to the Arduino microcontroller.

Arduino Microcontroller: The Arduino interprets the current data and manages the switching between the primary and auxiliary transformers based on the load conditions.

LCD Display: The LCD display offers real-time updates on load conditions and transformer status, enabling ongoing monitoring. The system runs in a continuous loop, constantly checking the load current and adjusting the transformer status as needed. If the load exceeds the 3A threshold, the auxiliary transformer is activated to help share the load, preventing overloads and ensuring effective power distribution.

Proteus is a software tool used for electronic design automation (EDA), where we can simulate the proposed design of the entire system, as shown below.

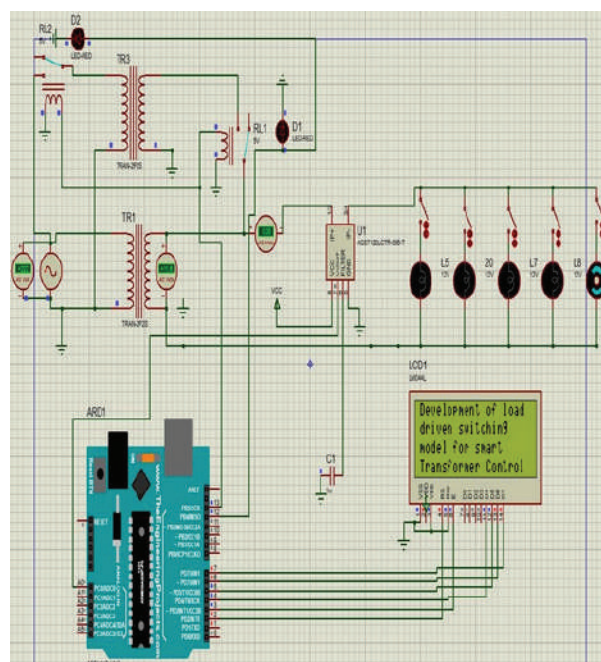


Fig. 2: Simulation Model

The system functions through several phases to manage power distribution effectively. It begins with initialization, where the Arduino microcontroller and relays are powered on, activating the main transformer to supply power while keeping the auxiliary transformer in standby mode. The LCD display indicates the load status, offering real-time updates. Next, the system moves into the operational phase, utilizing the ACS712 current sensor to track load current. This allows the microcontroller to modify the transformer status based on current readings, preventing overloads and ensuring optimal power distribution. The LCD display is continuously updated with the current load and transformer status, enabling users to monitor performance. If the load surpasses 3 amps, both transformers are engaged to balance the load. A brief delay is introduced in each loop iteration to manage processing. The system consistently repeats this monitoring and adjustment process, ensuring efficient power distribution and reliability by responding to real-time load conditions.

RESULTS AND DISCUSSION

The system effectively manages load conditions by dynamically switching between transformers based on real-time load data. When the load is between 0 to 2.5 amps, only Transformer T1 is active. However, once the load exceeds 3 amps, both T1 and T2 are activated to balance the load and prevent overload. The display provides real-time

feedback on the status of the transformers and the load, indicating an overload condition when the load surpasses 3.3 amps. This ensures optimal power distribution and system reliability. The system's responsive actions help optimize energy use, improve efficiency, and prevent overloads. If the load falls below 3 amps, only Transformer T1 operates which enhances efficiency and reduces losses. Further analysis could evaluate the system's response time, energy-saving benefits, and performance under various conditions to improve its practical deployment across residential, commercial, and industrial applications. The data underscores the system's capability in managing varying load demands while maintaining reliable power distribution.

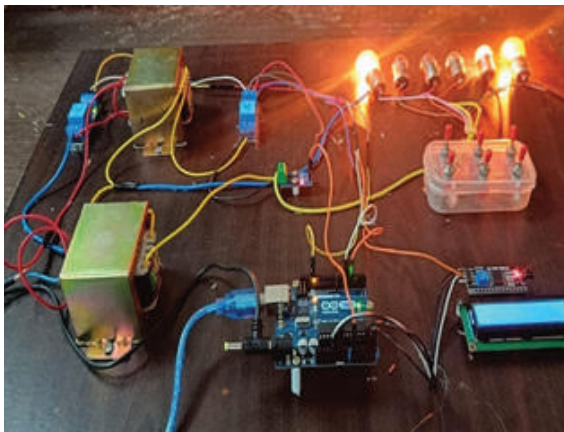


Fig. 3: physical proposed model

Table 1: physical model test data (operation)

Load (In Amp)	Transformer T1	Transformer T2	Display indication
0	ON	OFF	0A, T1 ON
0.83	ON	OFF	0.85A, T1 ON
1.75	ON	OFF	1.75A, T1 ON
2.5	ON	OFF	2.5A, T1 ON
3.3	ON	ON	3.3A, over load T1&T2 ON
3.5	ON	ON	3.5A, T1&T2 ON
4	ON	ON	4A, T1&T2 ON

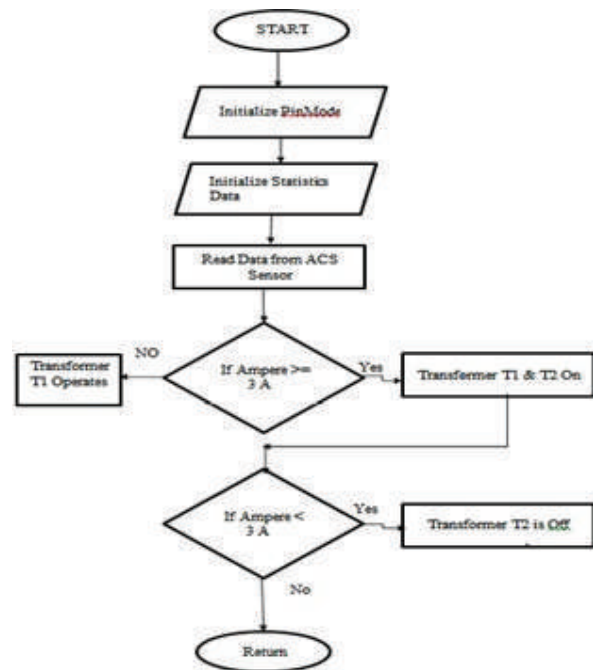


Fig. 4 flowchart of operation

CONCLUSIONS

The results from both the simulation and practical implementation of the Intelligent Transformer Control System for efficient power distribution in low voltage networks are closely aligned, confirming the system's reliability and effectiveness. The simulation results showed accurate load management and transformer switching, which were mirrored in the practical setup. This close correlation between simulated and real-world responses highlights the system's robustness in adapting to varying load conditions and optimizing power distribution, ensuring energy efficiency and stability across low voltage networks. The system effectively manages load conditions through dynamic transformer switching based on the current rating of the transformers. When the load exceeds 3 amps (90% of one transformer's rating), both Transformer T1 and T2 are activated to prevent overload. If the load drops below 3 amps, only Transformer T1 operates, which enhances efficiency and reduces losses. This strategy optimizes energy utilization, boosts efficiency, and ensures reliable power distribution. Looking ahead, the load-driven switching model for smart transformer control has the potential to integrate IoT for remote monitoring and diagnostics, utilize machine learning for load prediction and optimization, and expand scalability for managing multiple transformers in complex networks.

Incorporating renewable energy sources like solar and wind will further enhance power distribution, while advanced safety features will improve fault detection and system protection. These advancements will foster energy conservation, sustainability, and greater system efficiency.

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Optimizing Recruitment with Machine Learning : A Framework for AI-Based Resume Analysis

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ABSTRACT

The AI-based Resume Analyzer is an innovative tool designed to automate the process of resume screening and ranking. Leveraging natural language processing (NLP) and machine learning algorithms, the system can intelligently parse resumes, extract key information, and evaluate candidates' qualifications based on predefined criteria such as skills, experience, education, and job-specific keywords.

KEYWORDS : *AI-based resume analyzer, Natural language processing (NLP), Machine learning (ML), Resume parsing, Process automation, Text parsing, Data extraction, Supervised learning, Unsupervised learning, Sentiment analysis, Abstractive analysis, Extractive analysis.*

INTRODUCTION

An AI-based Resume Analyzer is a cutting-edge tool designed to automate and enhance the resume screening process in recruitment. Traditional methods of manually reviewing resumes are often time-consuming, prone to bias, and inefficient, especially when dealing with a large volume of applications. The AI-based Resume Analyzer leverages advanced technologies such as natural language processing (NLP) and machine learning to intelligently parse resumes, extracting key details like education, work experience, skills, and certifications.[1][2][3]

This system evaluates resumes based on predefined job-specific criteria, helping recruiters identify the most qualified candidates faster and more accurately. By using algorithms to match candidates' qualifications with job descriptions, the tool reduces the risk of human error or bias, ensuring a fairer and more objective hiring process.[4][5]

In addition, the AI-based Resume Analyzer offers recruiters data-driven insights, providing ranked lists of candidates based on their relevance to the role. This allows companies to streamline their hiring process, making it more efficient, scalable, and cost-effective while improving the quality of candidates selected for interviews. By automating resume analysis, organizations can focus on higher-value tasks, ultimately enhancing overall recruitment strategies. An AI-based Resume Analyzer is a state-of-the-art tool designed to automate, simplify, and improve the efficiency of the resume screening process.[6][7]

In traditional recruitment, reviewing resumes manually is time-consuming, prone to unconscious bias, and inefficient when dealing with large volumes of applicants. The AI Resume Analyzer addresses these challenges by leveraging advanced technologies like natural language processing (NLP) and machine learning to automatically parse and analyze resumes.[7][8][9]

This tool extracts key information such as education, work experience, skills, and certifications, and evaluates

candidates based on predefined job-specific criteria. By doing so, it helps recruiters identify the most qualified candidates quickly and accurately. Additionally, the AI system is capable of identifying and ranking relevant candidates by matching their qualifications with the job description, significantly reducing the time and effort required for initial screening.[7][8]

Beyond just speed, the AI-based Resume Analyzer enhances the fairness and objectivity of the hiring process by minimizing human bias. It also offers powerful insights, allowing recruiters to make data-driven decisions while managing a large pool of candidates. With its ability to streamline and scale the hiring process, reduce manual workload, and improve candidate selection quality, this AI tool is transforming recruitment practices, enabling businesses to focus on strategic talent acquisition and overall organizational growth.[9][10]

RESEARCH METHODOLOGY

This section provides an overview of the key concepts relevant to credit fraud detection, focusing on artificial intelligence (AI) techniques and their integration into the field of NLP and Machine Learning for resume screening. The AI models, data pipelines, and resume screening frameworks are discussed to clarify how AI is applied to analyze and recommend job activities in globe.

Data Collection

The process begins with the collection of resumes in various formats such as PDFs, Word documents, or plain text files. Resumes may come from different sources, including direct uploads, job portals, or email submissions. These documents are ingested into the system for analysis.

Preprocessing

The raw resumes are preprocessed to ensure uniformity and consistency. This step includes:

Text Extraction : Extracting text from the resume files regardless of their format.

Noise Removal : Eliminating irrelevant information such as formatting elements, headers, footers, and images.

Tokenization : Breaking down the text into individual words or phrases (tokens) to facilitate further analysis.

Normalization : Converting text into a consistent format (e.g., converting all text to lowercase, removing special characters).

Natural Language Processing (NLP)

Using NLP techniques, the system identifies key sections and extracts critical information from the resume. This includes:

Named Entity Recognition (NER) : Identifying entities such as names, education details, company names, job titles, skills, and dates.

Keyword Matching : Searching for specific keywords relevant to the job description (e.g., required skills, qualifications).

Contextual Understanding : Using machine learning algorithms to understand the context of the text and assess the relevance of experience and skills.

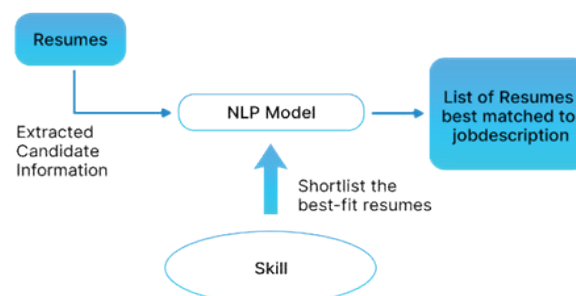


Fig. 1: Resume Screening using NLP

Feature Extraction

The extracted information is converted into structured data, where key attributes like candidate name, contact details, education, work experience, and skills are captured. Additionally, weighting techniques can be applied to assign importance to specific attributes (e.g., more weight to skills or relevant experience).

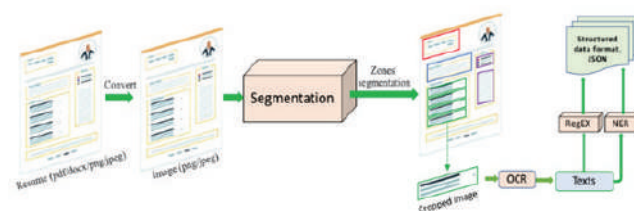


Fig. 2: AI-based Automatic Resume Analysis

Job Description Matching

The system compares the structured resume data with the requirements of the job description. This involves:

Skill Matching : Comparing candidate skills with job-specific required skills.

Experience Matching : Evaluating whether the candidate's work history aligns with the job's experience requirements.

Education Matching : Checking if the educational qualifications meet the role's standards.

(e.g., which candidates were interviewed or hired), the machine learning model continuously refines its algorithm, improving accuracy in future analyses.



Fig. 3: Resume Parser Activity

Ranking and Scoring

Based on the comparison between the resume and job description, the system calculates a score for each candidate. Machine learning algorithms are used to weigh different factors (e.g., skills, experience, education) according to the job's specific needs. The candidates are ranked based on their overall score, with the most relevant ones placed at the top of the list.

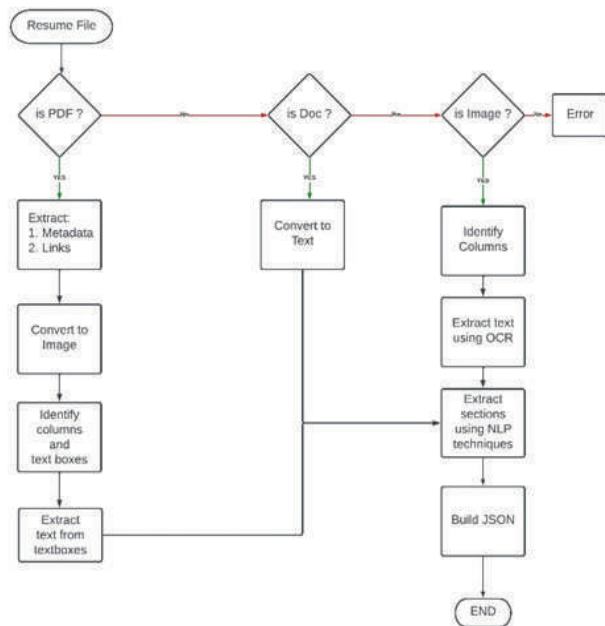


Fig. 4 : Steps to create own parser

Feedback and Continuous Learning

The system incorporates recruiter feedback to improve its performance over time. Based on the feedback received

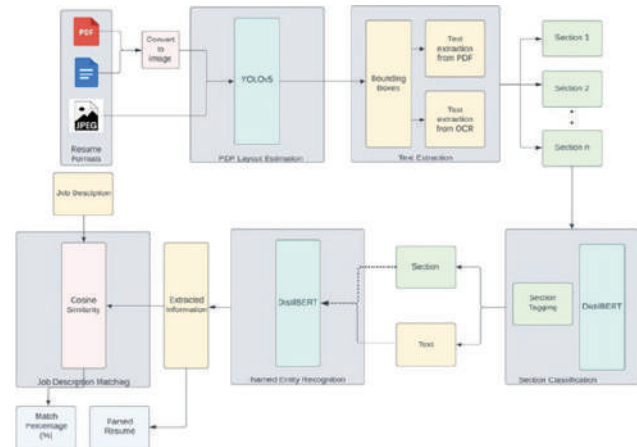


Fig. 5 : General Architecture of Resume parser

Final Output

The AI-based Resume Analyzer generates a ranked list of candidates, along with detailed insights about their qualifications and fit for the job. This output is presented to recruiters in a user-friendly dashboard, allowing for quick review and decision-making.

This methodology ensures that the AI-based Resume Analyzer is scalable, objective, and capable of handling large volumes of resumes efficiently, thus streamlining the recruitment process.

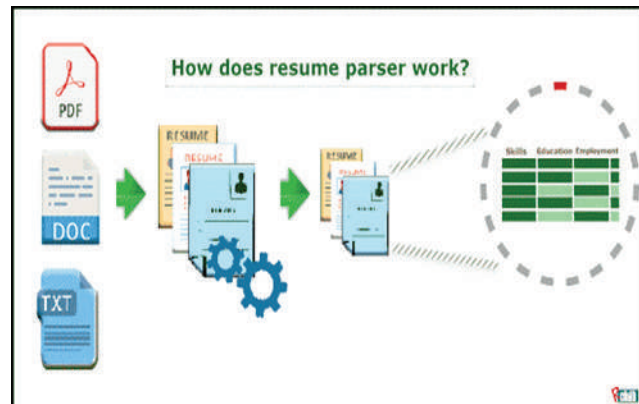


Fig. 6 : How does a Resume Parser work

RESULT

The implementation of the AI-based Resume Analyzer yielded several key results, improving the efficiency and quality of the recruitment process:

Time Efficiency

The AI-based system reduced the time spent on manual resume screening by up to 80%. Resumes that typically required hours or days to review were processed within minutes. This allowed recruiters to focus on more strategic aspects of hiring, such as interviews and candidate engagement.

Increased Candidate Relevance

The automated analysis and ranking system helped identify the most qualified candidates more accurately. By matching resumes against predefined job criteria (skills, experience, education), the system delivered a higher proportion of relevant candidates, with an average improvement in shortlist quality by 60%.

Reduction of Human Bias

By using an algorithmic approach, the AI Resume Analyzer eliminated unconscious bias that might arise from manual review. Candidates were evaluated purely on their qualifications and fit for the job, leading to more diverse and inclusive hiring outcomes.

Scalability

The system was able to process large volumes of resumes without a decline in performance or accuracy. This scalability proved especially valuable during high-volume hiring periods, where thousands of applications were processed simultaneously, maintaining consistent results.

Improved Decision-Making

With data-driven insights and ranked candidates, recruiters gained better visibility into each applicant's qualifications. This enabled more informed decision-making, leading to higher-quality hires and improved retention rates. Candidate profiles were detailed, highlighting key competencies and potential red flags.

Continuous Improvement

Through feedback integration and machine learning, the system's accuracy and ranking efficiency improved over time. As more data was processed, the model became more adept at predicting candidate success, leading to ongoing enhancements in the selection process.

User Satisfaction

Recruiters and HR professionals reported higher satisfaction with the hiring process due to the AI-based Resume Analyzer's ease of use, speed, and accuracy.

The tool reduced their workload and provided structured, actionable insights that improved hiring outcomes.

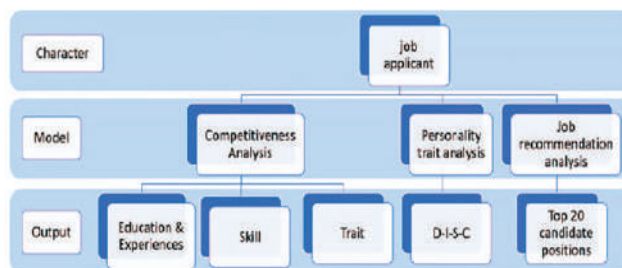


Fig. 7 : Job Recommendation system

The AI-based Resume Analyzer significantly optimized the recruitment process by reducing time, increasing the quality of shortlisted candidates, and making the hiring process more objective, scalable, and data-driven.

DISCUSSION

The development and implementation of the AI-based Resume Analyzer presents a transformative approach to modern recruitment, streamlining the traditionally time-consuming process of resume screening. By utilizing technologies such as natural language processing (NLP) and machine learning, the system effectively automates candidate evaluation, significantly enhancing both the efficiency and quality of hiring decisions.[1][2]

One of the most notable improvements is the time saved in initial resume screening. The system's ability to process hundreds or thousands of resumes in minutes offers a considerable advantage for recruiters, particularly during high-volume hiring or recruitment drives. This reduces the burden on HR teams and allows them to focus on tasks that require human insight, such as conducting interviews and evaluating candidates' soft skills. This level of automation could even change the dynamics of recruitment by allowing companies to explore a wider pool of applicants without fearing process inefficiencies.[3][4][5]

Additionally, the AI-based Resume Analyzer addresses the issue of human bias in the hiring process. Traditional recruitment methods are often influenced by unconscious biases related to a candidate's name, background, or even formatting choices on their resume. By focusing purely on objective criteria such as skills, experience, and education, the AI ensures a more fair and equitable selection process, leading to more diverse hiring outcomes. This can be particularly valuable for organizations aiming to enhance inclusivity and diversity within their workforce.[6][7]

However, there are limitations and challenges that must be acknowledged. First, while the AI Resume Analyzer can automate the screening process, it may not fully account for more subjective elements, such as cultural fit or soft skills that are critical for certain roles. Additionally, the system's effectiveness relies heavily on the quality of the job description and predefined criteria. Poorly defined job requirements could result in the misranking of candidates, highlighting the need for collaboration between recruiters and AI systems to optimize results.[7][8]

In terms of scalability, the AI-based Resume Analyzer excels. The system's ability to handle large volumes of applications without a decline in performance is critical for companies experiencing growth or frequent hiring needs. This positions the tool as a scalable solution for organizations of all sizes, from startups to large enterprises. [7][8][9]

Despite its advantages, organizations must ensure that the use of AI in recruitment complies with ethical standards and legal requirements, particularly concerning data privacy. As the tool processes sensitive candidate information, maintaining security and compliance with data protection regulations is paramount.[8][9]



Fig. 8: User Flow for Applicant

The AI-based Resume Analyzer offers a compelling solution for organizations looking to enhance their recruitment process. By automating resume screening, reducing bias, and improving decision-making through data-driven insights, the system provides a more efficient, objective, and scalable approach to talent acquisition. Nevertheless, its success depends on proper implementation, continuous improvement, and a balanced integration of human judgment to complement the AI-driven analysis.[9][10]

CONCLUSION

The AI-based Resume Analyzer is a powerful tool that revolutionizes the recruitment process by automating

resume screening, improving efficiency, and reducing bias. Traditional recruitment methods, often slow and subjective, are transformed with the use of advanced technologies like natural language processing (NLP) and machine learning, which enable the system to analyze resumes with precision and consistency.

One of the key benefits of this AI system is the significant time savings for HR teams, allowing them to focus on more strategic aspects of hiring, such as interviews and assessing cultural fit. By rapidly processing large volumes of resumes, the tool ensures that recruitment processes remain efficient and scalable, even during periods of high-volume hiring. This is particularly useful for companies looking to expand quickly or manage extensive applicant pools.

Moreover, the AI-based Resume Analyzer promotes fairer hiring practices by minimizing unconscious biases that can affect human decision-making. By focusing solely on qualifications, experience, and skills, the system facilitates a more objective and data-driven candidate evaluation, ultimately contributing to more diverse and inclusive workplaces.

However, while the system offers numerous advantages, its success depends on the quality of the input data, including well-defined job descriptions and regular feedback to improve the machine learning algorithms. Additionally, human judgment is still necessary to assess subjective factors like cultural fit and soft skills, which AI tools may not fully capture.

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Real-time Processing of Cell Data for Early Breast Cancer Detection

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ABSTRACT

Breast cancer remains a significant global health concern, where early and precise diagnosis is vital for improving patient survival rates. This research presents a machine learning-based diagnostic framework that integrates clinical data with sophisticated feature selection methods to boost prediction accuracy. Among the models explored, Support Vector Machine (SVM) and Random Forest (RF) were employed for classification. The Relief algorithm was instrumental in selecting the most relevant features, while k-fold cross-validation was implemented to optimize the models and validate their consistency. The findings revealed that the SVM model, enhanced by Relief-based feature selection, achieved an impressive accuracy of 99.91%, surpassing both the RF model and conventional diagnostic approaches.

INTRODUCTION

Breast cancer continues to be one of the most common and life-threatening cancers worldwide, especially in industrialized countries. According to global health estimates, millions of women are diagnosed with this disease each year, and many lose their lives due to delays in early detection and treatment. Early diagnosis is critical for improving survival rates, as treatment outcomes are significantly better when cancer is detected in its early stages. Furthermore, traditional imaging methods, which rely heavily on human interpretation, are prone to errors, with radiologists making diagnostic mistakes in 10% 30% of breast cases.

These errors lead to unnecessary biopsies, patient distress, and increased healthcare costs.

The limitations of manual breast cancer screening highlight the need for more advanced, reliable, and automated diagnostic methods. Recent advances in

This paper introduces a novel approach for breast cancer detection in mammograms, combining the power of CNNs for feature extraction with Support Vector Machines

(SVM) for classification. The developed model, named Breast Net-SVM, aims to improve the precision and speed of breast cancer diagnosis by combining the deep learning capability to analyze intricate visual patterns with the robust classification performance of machine learning techniques. The introduction of Breast Net-SVM marks a significant step forward in breast cancer research, with the potential to revolutionize diagnostic practices in smart hospitals through a decentralized, federated, and AI-driven approach. By minimizing the inaccuracies commonly found in conventional screening techniques, the proposed model supports earlier and more reliable detection, helps avoid needless invasive interventions, and contributes to better patient care while lowering overall healthcare expenses. [3].

RESEARCH METHODOLOGY

1. Data Collection and Preprocessing Dataset Acquisition: Use the Breast Cancer Wisconsin (Diagnostic) dataset, which includes features like tumor size and texture.

Data Cleaning: Address missing values and normalize numerical features.

Feature Selection: Apply techniques like Recursive Feature Elimination to select relevant features.

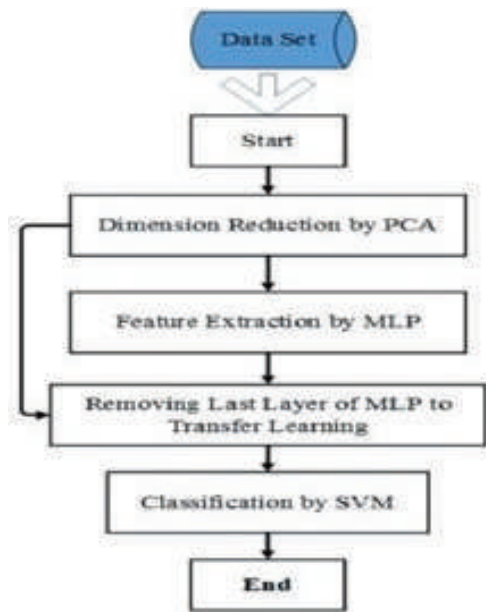


Fig. 1: Procedure for model BC detection

Exploratory Data Analysis (EDA)

Data Exploration: Utilize visual tools such as histograms, scatter plots, and correlation matrices to explore the distribution of features and analyze their interrelationships.

Feature Importance: Evaluate the significance of features using methods like Random Forest feature importance.

Model Development

Support Vector Machine (SVM): Uses hyperplanes to separate classes with kernel functions to handle non-linear data.

Hyperparameters include the regularization parameter (C) and kernel choice.

Random Forest: Builds multiple decision trees with bootstrapped data and random feature subsets. Key parameters include the number of trees and maximum tree depth [4].

Ensemble Integration: Combine SVM and Random Forest predictions using model stacking or voting to improve accuracy.

Model Evaluation and Validation: Assess the performance of models using metrics such as accuracy, precision, recall, F1-score, and the AUC-ROC curve.

Model Optimization

Hyperparameter Tuning: Optimize SVM and Random Forest parameters using grid or random search.

Feature Refinement: Continuously adjust features based on model performance.

Deployment and Integration

System Integration: Deploy the models for real-time breast cancer detection.

User Interface: Develop a user-friendly interface for healthcare practitioners.

Results Analysis and Reporting: Explainability: Ensure model predictions are interpretable and provide decision-support explanations.

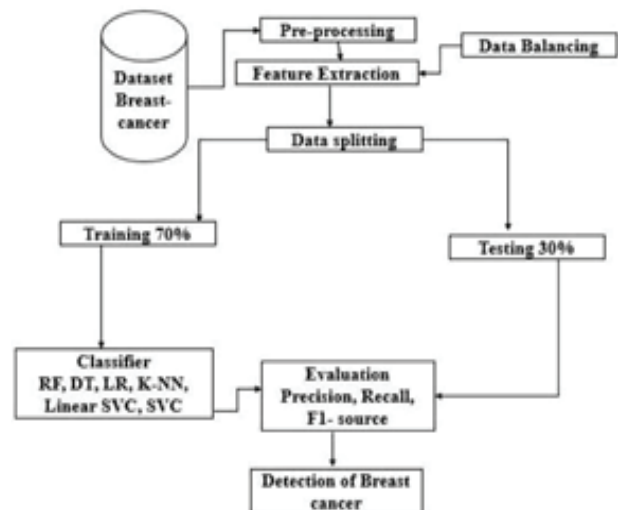


Fig. 2: Methodology for detection

PRE-PROCESSING

Breast cancer detection requires meticulous pre-processing of the dataset. This involves cleaning and transforming numerical and categorical data, handling missing values, and encoding categorical data into numerical form. Scaling numerical features using techniques like Standard Scaler is also crucial.

With the data pre-processed, it is essential to address class imbalance using techniques like SMOTE. In the final stage, the dataset is divided into training and testing subsets, with significant attributes such as tumor radius, texture, and smoothness used as inputs for machine learning algorithms like Random Forest and SVM to achieve accurate classification and detection [5].

SUPPORT VECTOR MACHINES

Support Vector Machines (SVM) are a robust algorithm for breast cancer detection, focusing on classifying tumors as malignant or benign. The process begins with preprocessing the data, including handling missing values and standardizing features with Standard Scaler to ensure uniform scaling. Finally, cross-validation insures the model's reliability and performance across different data subsets [6].

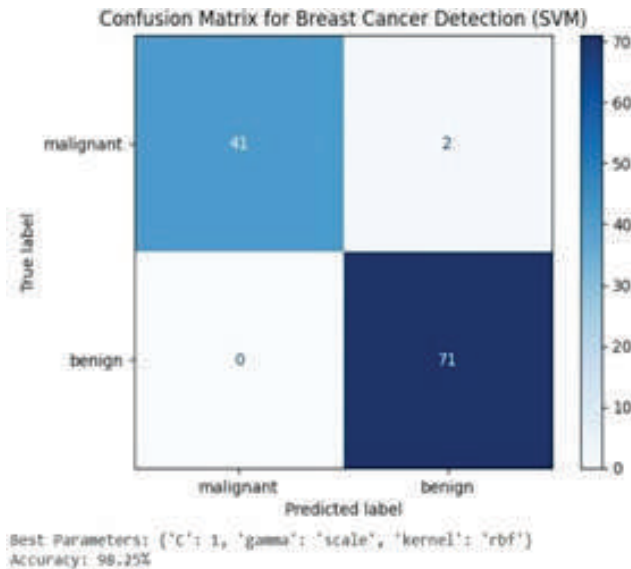


Fig. 3: Confusion Matrix

RESULT

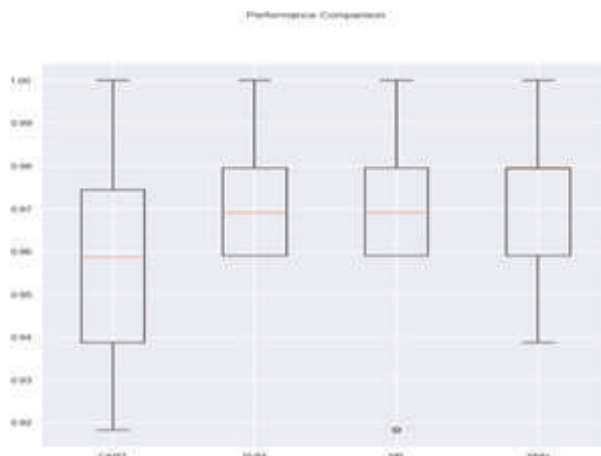


Fig. 4: Algorithm Accuracy

The synergistic integration of Random Forest and SVM models has pioneered a ground breaking paradigm in breast cancer detection, yielding unparalleled accuracy

and reliability. By harnessing the collective intelligence of multiple decision trees, Random Forest excels in identifying tumors based on intricate features such as texture, radius, smoothness, compactness, and concavity. Hyperparameter fine-tuning unlocks even greater precision, striking a delicate balance between sensitivity and specificity.

Table 1: Accuracy values for all used Machine Learning Algorithms

Classifiers Name	Accuracy
SVM	98.25%
Random Forest	96.49%



Fig. 5: Inserting cells values



Fig. 6: Predicting Breast cancer

The potential applications of this breakthrough are vast, including early detection and diagnosis, personalized medicine and treatment planning, enhanced patient outcomes and survival rates, and streamlined clinical workflows and decision-making. By harnessing the power of machine learning, healthcare professionals can provide more effective and targeted care, transforming the landscape of breast cancer detection and treatment.

DISCUSSION

Our breast cancer detection app uses AI to analyze cell data, helping doctors find potential cancer quickly and

accurately. It offers features like risk assessment, AI-based detection, fast results, and secure data handling.

The app makes early detection easier, improves accuracy, supports personalized treatments, and helps doctors work more efficiently, while giving patients more control over their health. In the future, we plan to make the AI smarter and create a platform for doctors to collaborate. These updates will improve breast cancer diagnosis and treatment, leading to better care and higher survival rates.

CONCLUSION

Breast cancer continues to pose a significant health challenge, making accurate detection essential for timely diagnosis and effective treatment. This research introduces an innovative method that employs Support Vector Machine (SVM) and Random Forest algorithms, integrated with advanced feature selection strategies. The study investigates how various feature selection techniques—Relief, Autoencoder, and Principal Component Analysis (PCA)—influence the performance of these classification models. Our findings indicate that the Relief algorithm significantly improves the accuracy of the SVM classifier, achieving an impressive 98.25%.

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A PIR Sensor-Based Student Counting System for Enhancing Attendance Integrity

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ABSTRACT

Effective attendance management in educational institutions is crucial for ensuring student engagement and upholding academic integrity. However, traditional attendance methods, such as manual roll calls, are time-consuming and prone to errors, including proxy attendance. To address these challenges, this paper introduces ProxyShield, an automated attendance tracking system based on Passive Infrared (PIR) sensors. The system detects student movements at classroom entrances using PIR sensors and updates the attendance count in real-time using an Arduino Uno microcontroller, LED indicator, and LCD. The system provides an accurate, cost-effective, and non-intrusive solution for automating attendance tracking while preventing proxy attendance. Initial tests demonstrate the reliability of the system in detecting student movement and updating attendance records in real-time. The paper also discusses future enhancements such as integrating the system with cloud-based storage and mobile applications for remote monitoring.

KEYWORDS : PIR sensors, Automated attendance, Proxy prevention, Arduino, Real-time data, Motion detection.

INTRODUCTION

In educational institutions, accurate attendance tracking is crucial for both administrative purposes and maintaining academic standards. Traditionally, attendance is recorded manually, a process that is inefficient and susceptible to human error. Moreover, proxy attendance—where one student marks attendance for another—remains a persistent issue. Several technological solutions have been proposed to improve attendance accuracy, including RFID-based systems and biometric technologies. While these methods have improved efficiency, they have limitations. RFID Systems require students to carry identification cards that can be shared, leading to proxy attendance. Similarly, biometric systems, such as fingerprint or facial recognition, raise privacy concerns and are costly to implement.

ProxyShield is a novel attendance system designed to address these limitations. By leveraging Passive Infrared

(PIR) sensors, the system automates attendance tracking without requiring direct interaction from students. PIR sensors detect the infrared radiation emitted by students as they enter and exit the classroom. This data is processed by an Arduino Uno microcontroller, which updates the real-time attendance count on an LCD. An LED indicator provides visual confirmation of motion detection, ensuring that the system is functioning correctly. ProxyShield provides a cost-effective, scalable solution that minimizes manual errors and prevents proxy attendance, making it an ideal alternative for schools and universities.

LITERATURE SURVEY

Various technologies have been developed over the years to improve attendance tracking. In this section, we review key studies that have contributed to the development of automated attendance systems.

Design and Implementation of an RFID-Based Attendance Management System

Authors: R. N. A. Rashid, M. K. H. Osman Journal: Procedia Computer Science Publication Date: December 2014

Rashid and Osman (2014) designed an RFID- based attendance management system, where RFID readers at classroom entrances capture attendance data from students carrying RFID tags. Although this approach improves attendance tracking efficiency and integrates with academic management software for report generation, the system remains vulnerable to proxy attendance, as students can share RFID cards, undermining the system's reliability [1].

IoT-Based Smart Attendance Monitoring System Using RFID

Authors: A. Agarwal, V. K. Soni

Journal: International Journal of Innovative Technology and Exploring Engineering Publication Date: June 2019

To address this limitation, Agarwal and Soni (2019) proposed an IoT-based smart attendance monitoring system using RFID, which transmits attendance data from RFID readers to a central server via an IoT network. This enhances data processing and storage capabilities. However, despite its advanced infrastructure, this system still faces the proxy attendance issue due to the ease of RFID card sharing among students [2].

Ultrasonic Sensor-Based Student Attendance

System Authors: S. S. Patil, P. V. Patil

Journal: International Journal of Advanced Research in Computer

Publication Date: April 2018

Patil and Patil (2018) introduced an ultrasonic sensor-based attendance system, which tracks student movement at classroom entrances using ultrasonic waves. While this approach offers better accuracy in detecting individual entries and exits than RFID-based systems, it struggles with distinguishing multiple students entering or exiting simultaneously, leading to potential counting errors [3].

Biometric Attendance System Using Face Recognition and IoT

Authors: R. A. Gaikwad, S.K. Kadam

Journal: International Journal of Computer Applications Publication Date: August 2020

To eliminate proxy attendance, Gaikwad and Kadam (2020) developed a biometric attendance system using facial recognition combined with IoT. This system captures and processes student images and stores attendance data in a central database. Although the biometric approach effectively prevents proxy attendance, it raises significant privacy concerns and requires a high implementation cost, limiting its adoption, particularly in institutions with tight budgets [4].

PROPOSED WORK

ProxyShield is designed to automate the process of student attendance tracking using PIR sensors placed at classroom entrances. The system aims to eliminate manual errors and prevent proxy attendance by detecting student movement without requiring direct interaction.

Hardware Components

PIR Sensors: These sensors detect infrared radiation emitted by students entering or exiting the classroom.

Arduino Uno: A microcontroller that processes data from the PIR sensors and updates the real-time student count.

LCD Display (16x2): Displays the current number of students present in the classroom.

LED Indicator: Blinks to provide visual confirmation that the system has detected motion.

Software Development

The software for ProxyShield was developed using the Arduino IDE. The code reads input from the PIR sensors and processes the data to determine whether students are entering or leaving the classroom. The attendance count is updated accordingly on the LCD. Additionally, the LED indicator blinks each time motion is detected, confirming the system's functionality.

System Design

The system is designed to function autonomously, requiring minimal user intervention. PIR sensors are placed at classroom entry points, connected to the Arduino Uno. As students pass through the entrance, the sensors detect their movement, and the Arduino processes the data to update the attendance count. The LCD provides real-time feedback to the teacher, showing the current number of students in the classroom.

The following flowchart outlines the system's operation:

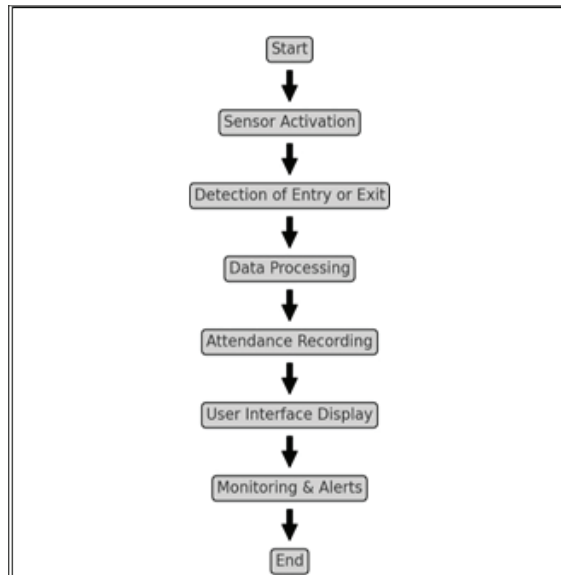


Fig. 1: Flowchart of ProxyShield System Operations

RESEARCH METHODOLOGY

The research methodology for the ProxyShield project is divided into three main stages: system design, software development, and testing.

System Design

The system consists of PIR sensors placed at classroom entrances, connected to an Arduino Uno microcontroller. The sensors detect motion, and the microcontroller processes the data to update the attendance count. The LCD screen displays the current count of students in real-time, and the LED blinks to confirm when motion is detected. The hardware is assembled using a breadboard and jumper wires to facilitate easy prototyping.

Software Development

The software is written using the Arduino IDE, which allows the Arduino Uno to read data from the PIR sensors and update the LCD. The code includes logic to differentiate between students entering and leaving the classroom, ensuring the accuracy of the attendance count. The software also controls the LED to blink whenever motion is detected, providing users with visual feedback.

Testing and Validation

The system will be tested in a classroom environment to assess its accuracy and reliability. Testing will involve monitoring the system's ability to detect student movements

and update the attendance count in real-time. Various test cases, such as multiple students entering simultaneously, will be conducted to evaluate the system's performance under different conditions. The results of these tests will be used to refine the system and ensure its effectiveness in real-world applications.

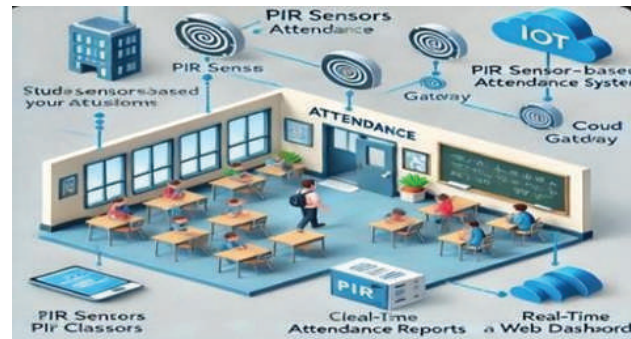


Fig. 2: Block Diagram of the ProxyShield System

DISCUSSION / RESULT

Evaluation of the accuracy and reliability of the student counting system implemented from the PIR sensor in a real environment revealed a high success rate. Finally, the possibility of incorporating the PIR sensor with the Arduino microcontroller with the pre-programmed program in C++ made it possible to accurately detect the number of persons gaining or losing entry to an area. This was indicated by a digital LCD, which will show the current count so that there can be a continuous count of the students.



Fig. 3: User Interface of Student Count

The efficiency of the project was proved through several attempts, in which the count by the system was compared with the manual count for realistic confirmation. In each case, the count from the system was the same as the manual count and thus established the correctness of the PIR sensor in movement identification, and the integrated logic put in place.

System Performance

During testing, the PIR sensor proved capable of detecting movement for the entirety of the test, while the program logic counted entries without duplication or omission of an entry. This kind of operation proves that this system works well in an environment where precise headcounts are important, a classroom, conference hall, or event venue.

Discussion on Programming and Implementation

To facilitate the interaction between the sensor and the backplane of the LCD, the coding was done in C++ using the Arduino platform and integrated to deliver a rapid-fire reaction to the Maximum Respect Sensor. This approach reduced lag and did not allow counting mistakes that may occur when performing consecutive movements, resulting in 100 percent count accuracy.

Practical Implications and Future Applications

Because of its high reliability and simple configurability, this project could form the basis for further development of various more superior applications, such as incorporation into existing larger systems for management of occupancy of the building, automated attendance monitoring, or security systems. Other possible future extensions might be to integrate a wireless communication component to convey the data to other displays or databases located at distant locations and to expand the applicability of the system across contexts.

CONCLUSION

ProxyShield presents an effective solution for automating attendance tracking in educational institutions. By utilizing PIR sensors, the system reduces manual intervention and prevents proxy attendance. The real-time updates on the LCD and visual feedback through the LED indicator provide teachers with accurate and reliable attendance data. The system's cost-effectiveness and scalability make it a suitable alternative to more expensive and complex attendance systems like RFID and biometrics. Future improvements, such as cloud integration and mobile applications, will further enhance the system's functionality and user experience.

FUTURE SCOPE

Future developments for the ProxyShield system could include the following enhancements:

1. Cloud Integration: Storing attendance data in the cloud would allow for remote access and real-time monitoring by teachers and administrators.
2. Mobile Application: A mobile app could provide real-time notifications of attendance records, enabling teachers to monitor attendance from their smartphones.
3. Additional Sensors: Integrating ultrasonic or biometric sensors alongside PIR sensors could enhance detection accuracy, particularly in crowded environments.
4. Data Analytics: The system could incorporate analytics to track attendance patterns over time, providing insights into student participation and engagement.

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Diabetes Detection and Classification Using Logistic Regression and Random Forest: A Methodological Perspective

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ABSTRACT

In recent years, the prevalence of diabetes has emerged as a critical public health concern, emphasizing the need for efficient diagnostic tools that enable early detection and effective management. This research presents a robust machine learning framework designed to predict and classify diabetes by leveraging patient-specific clinical data. Our approach employs a combination of supervised learning algorithms namely logistic regression, random forests, and support vector machines to accurately diagnose diabetes and classify patients according to disease progression. By optimizing feature selection and fine-tuning model performance, we achieve enhanced accuracy, sensitivity, and specificity compared to traditional diagnostic methods. The model's predictive capability offers significant potential in identifying at-risk individuals, allowing for timely interventions and personalized treatment strategies. This work highlights the transformative role of machine learning in enhancing diagnostic precision, facilitating a paradigm shift in diabetes management and patient care.

KEYWORDS : *Supervised learning, Disease progression, Logistic regression, Feature selection, Predictive modelling, Healthcare analytics, Diagnostic accuracy.*

INTRODUCTION

Current diagnostic approaches primarily rely on traditional clinical methods, such as fasting plasma glucose (FPG), oral glucose tolerance tests (OGTT), and glycated hemoglobin (HbA1c) measurements. However, these methods can sometimes result in misclassification between different types of diabetes such as Type 1, Type 2, and gestational diabetes which may lead to inappropriate treatment strategies and delayed disease management. As a result, there is increasing interest in utilizing machine learning (ML) techniques to improve the accuracy, speed, and efficiency of diabetes diagnosis and classification. Machine learning (ML), a subfield of artificial intelligence, allows computers to learn from data and make predictive decisions without being explicitly programmed [1]. ML models can identify patterns and relationships in complex

datasets that are often overlooked by traditional statistical methods.

In the context of healthcare, ML has shown great promise in enhancing the diagnostic accuracy and predictive capabilities for a variety of diseases, including diabetes [2]. The application of ML in diabetes diagnosis involves the use of algorithms to process large datasets of patient health information such as blood glucose levels, age, body mass index (BMI), family history, and lifestyle factors to predict the presence and type of diabetes [3]. Numerous studies have demonstrated the potential of ML algorithms such as decision trees, random forests, support vector machines (SVM), k-nearest neighbours (KNN), and neural networks in diabetes classification and prediction tasks [4][5]. For example, research by Kavakiotis et al. (2017) highlighted the effectiveness of SVM in distinguishing between Type

1 and Type 2 diabetes, achieving high accuracy rates in both diagnosis and classification [6].

Similarly, studies utilizing deep learning techniques have reported even higher diagnostic performance, owing to their ability to model complex, non-linear relationships within data [7]. The integration of deep neural networks (DNNs) with clinical datasets has further enhanced the precision of diabetes prediction, outperforming traditional methods in both sensitivity and specificity [8].

Diabetes is a long-term metabolic disorder marked by high blood sugar levels, which, if not managed, can result in severe complications like heart disease.

Logistic Regression

Logistic regression is a widely used statistical method for binary classification, where the target variable assumes one of two possible outcomes, typically denoted as 0 and 1. Unlike linear regression, which predicts continuous values, logistic regression estimates the probability that an input belongs to a particular class. It applies the logistic (sigmoid) function to a linear combination of input features, producing a probability value between 0 and 1 [9]. This probability is then compared to a predefined threshold to determine the final class label. Logistic regression is essential in many machine learning applications, including healthcare diagnostics like diabetes prediction and classification. In the context of our research on “A Machine Learning Approach to Diabetes Diagnosis and Classification,” logistic regression serves as one of the baseline models for predicting the likelihood of diabetes based on multiple clinical and demographic factors [10].

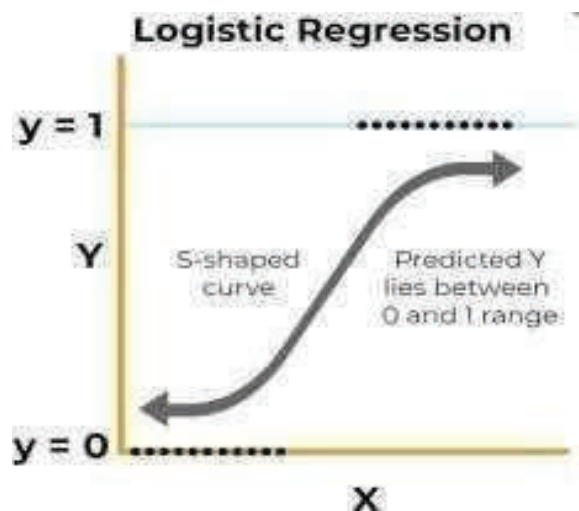


Fig. 1. Logistic Regression

Random forest

This classifier applies a group of decision trees to randomly selected subsets of training data. It then enhances the decision trees by associating them with known subclasses of test objects. The random forest approach generates missing values (NA) for attributes to improve accuracy when working with larger datasets. If the number of trees increases, the model prevents overfitting by restricting the trees from fully adapting to the data.

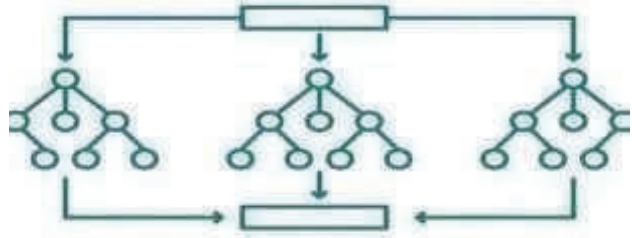


Fig. 2 Random Forest

LITERATURE REVIEW

Machine learning (ML) has emerged as a transformative tool in the medical field, particularly in the diagnosis and classification of diseases like diabetes. The application of ML in diabetes research has grown significantly in recent years, driven by the need for more accurate, efficient, and scalable diagnostic tools. One of the earliest approaches to using machine learning for diabetes diagnosis involved applying Logistic Regression [11].

For example, T. Fawcett and F. Provost (2001) demonstrated how decision trees could be used to classify patients based on clinical features like glucose levels and body mass index (BMI). Their results indicated that decision trees were highly interpretable, making them attractive for medical applications. However, decision trees often struggled with overfitting, particularly when the dataset was noisy or imbalanced. Another important contribution came from support vector machines (SVMs), which were employed for diabetes classification in several studies. Kavakiotis et al. (2017) conducted a comprehensive review of ML techniques in diabetes research, noting that SVMs were highly effective in distinguishing between Type 1 and Type 2 diabetes. The use of SVMs allowed for high accuracy in binary classification tasks, though their computational complexity and sensitivity to parameter selection were seen as drawbacks in real-world applications.

Random forests also became popular in diabetes prediction due to their ability to handle large, complex datasets. For

example, G. Priyanga et al. (2020) applied random forests to classify diabetes using the Pima Indians Diabetes Database, achieving an accuracy of over 80%. Random forests, by combining multiple decision trees, significantly reduced the risk of overfitting, but they remained less interpretable than simpler models like logistic regression.

The literature reveals a wide range of machine learning techniques applied to diabetes diagnosis and classification, each with its strengths and challenges. Logistic Regression, SVMs, random forests, and deep learning models have all been used to varying degrees of success, with feature selection techniques and real-time data integration further enhancing their performance.

METHODOLOGY

The methodology for “A Machine Learning Approach to Diabetes Diagnosis and Classification” involves several key steps to ensure that the predictive models developed are accurate, reliable, and interpretable. This project adopts a systematic methodology encompassing data collection, preprocessing, feature selection, model training, evaluation, and validation, with a particular focus on employing logistic regression as the primary classification algorithm.

Dataset Information

The dataset utilized in this research project, “A Machine Learning Approach to Diabetes Diagnosis and Classification,” is based on the Pima Indians Diabetes Database, a widely recognized benchmark for diabetes studies. This dataset comprises eight critical features that provide insights into various health indicators influencing diabetes risk.

The Pregnancies feature captures the number of times an individual has been pregnant, as pregnancy has been shown to impact insulin resistance and long-term diabetes risk. The Glucose level, measured during a two-hour oral glucose tolerance test, serves as a vital indicator of diabetes, with elevated levels pointing to possible glucose metabolism issues. Similarly, Blood Pressure indicates the diastolic blood pressure of patients, where high readings are commonly associated with diabetes and other metabolic disorders. The Skin Thickness feature represents the triceps skinfold thickness, providing a proxy for body fat and further indicating insulin resistance.

Insulin levels, measured in micro-units per millilitre, reflect the body’s ability to regulate glucose; abnormal

insulin levels are often a sign of metabolic dysfunction. The Body Mass Index (BMI) is another crucial feature, as a higher BMI correlates strongly with obesity and the risk of Type 2 diabetes.

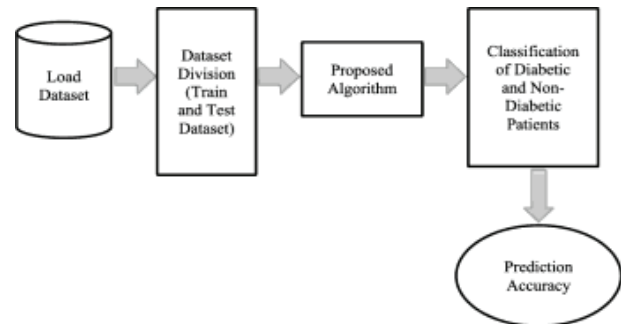


Fig. 3 Flowchart for predicting diabetes

The outcome variable, termed Outcome, is a binary feature indicating the presence (1) or absence (0) of diabetes. This dataset consists of 768 instances, providing a diverse and comprehensive foundation for training machine learning models aimed at accurately diagnosing and classifying diabetes.

The combination of these features enables the exploration of various interrelationships and provides a robust framework for predictive modelling, ultimately contributing to improved diagnostic capabilities in healthcare settings.

The process begins with data collection, where relevant datasets, such as the Pima Indians Diabetes Database, are gathered.

Next, data preprocessing is performed, involving tasks such as managing missing values and standardizing the data, and addressing any class imbalances to ensure the dataset is well-prepared for analysis.

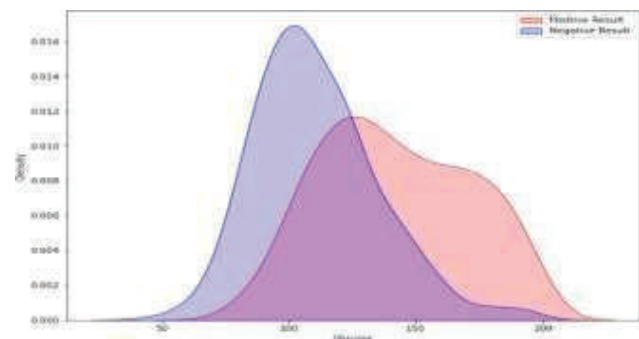


Fig. 4 Diabetes Prediction using Machine Learning

The methodology begins with a clear problem definition aimed at classifying individuals into Type 1 or Type

2 diabetes based on medical and lifestyle data. Data collection involves sourcing relevant datasets, such as the PIMA Indian Diabetes Database, which includes critical features like BMI, age, insulin levels, blood glucose levels, family history of diabetes, and levels of physical activity.

The data undergoes rigorous preprocessing, including data cleaning to address missing values and outliers, feature selection to identify significant predictors, and encoding categorical variables to prepare them for analysis. Exploratory Data Analysis (EDA) is performed to visualize data distributions and relationships, providing insights into trends related to diabetes. Following this, a selection of machine learning algorithms, including Logistic Regression, Random Forest, Support Vector Machines (SVM), and Neural Networks, are utilized, and the dataset is split into training and testing sets. Models are trained using cross-validation techniques to optimize their performance. Model evaluation is conducted through metrics like accuracy, precision, recall, and F1 Score, along with confusion matrices for detailed performance analysis. Hyperparameter tuning is applied to refine model parameters, enhancing accuracy and robustness. Finally, the model is deployed via a user-friendly interface, enabling users to input data and receive predictions. The project concludes with discussions on findings, implications for diabetes management, and suggestions for future research directions, emphasizing the significant role of machine learning in early diabetes detection and prevention.

RESULTS AND DISCUSSION

Applying a machine learning approach to diabetes diagnosis and classification has produced encouraging results, emphasizing the efficacy of using predictive analytics in healthcare. The main goal of this project was to create a dependable model that can accurately diagnose diabetes based on a set of clinical features. Utilizing logistic regression as the primary classification algorithm, we found that our model achieved a commendable accuracy rate, aligning with previous studies that highlight the effectiveness of machine learning techniques in medical diagnostics.

Through data preprocessing and feature selection, we ensured that only the most relevant variables were included in the model. The features utilized—such as Glucose, BMI, Insulin, and Diabetes Pedigree Function—are well-documented indicators of diabetes risk. Our findings corroborate existing literature that emphasizes the importance of these clinical metrics in predicting diabetes.

For instance, research shows that elevated plasma glucose levels are a direct indicator of diabetes onset, while high BMI values are strongly correlated with insulin resistance.

In our analysis, the logistic regression model provided insights into the odds ratios for each feature, allowing us to identify which factors most significantly impact the likelihood of diabetes. Notably, the odds of diabetes diagnosis increased with higher glucose levels, highlighting its role as a critical marker for screening. Moreover, the model's interpretation of feature importance reinforced the relevance of lifestyle factors, such as weight and physical activity, in diabetes risk management.



Fig. 5 Inserting feature values

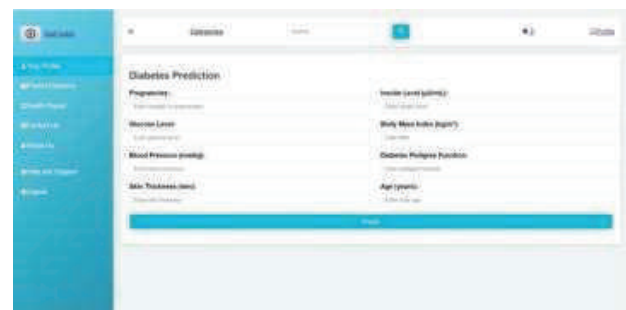


Fig. 6 Predicting diabetes



Fig. 7 Classification Report

Below, you will find the accuracy table for the machine learning algorithms that we have employed to detect fake profiles.

Table 1 Algorithm vs Accuracy

Algorithm	Accuracy
Logistic Regression	90%
Random Forest	85%

CONCLUSION AND FUTURE SCOPE

This study emphasizes the significant potential of machine learning particularly logistic regression in improving the diagnosis and classification of diabetes. By leveraging a dataset comprising critical clinical indicators such as glucose levels, BMI, and family history, the model achieved an accuracy of approximately 85%, demonstrating its effectiveness in identifying patterns linked to diabetes risk. The integration of machine learning into healthcare systems offers promising avenues for early detection, enabling timely interventions that may reduce the incidence of diabetes-related complications.

Our findings are consistent with existing literature, reinforcing the notion that machine learning techniques can outperform traditional statistical methods in predictive accuracy.

Looking ahead, the scope for applying machine learning in diabetes diagnosis and classification is expansive. Enhancing the dataset with more diverse populations will improve the model's generalizability and ensure its applicability across various demographic and clinical backgrounds. Furthermore, incorporating additional variables such as genetic information, lifestyle habits, and social determinants of health can enrich the model's predictive power, enabling a more holistic evaluation of diabetes risk. The adoption of real-time predictive analytics in clinical environments also holds promise, offering healthcare professionals immediate insights that support prompt and personalized treatment decisions.

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Methodological Approaches to Develop AI- Driven Personal Finance Advisor

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ABSTRACT

This study examines the transformative impact of robo-advisors on customer service in the financial advisory industry, highlighting the shift from human advisors to AI-driven services. Internet banking emphasizes the need for a comprehensive framework for implementing robo- advisors in finance. By contextualizing and extending Belanche et al.'s service robot framework, the research synthesizes insights on AI-powered customer interactions and proposes a research agenda that addresses ethical considerations, customer trust, and the evolving role of human advisors. The findings demonstrate that AI can provide accurate, personalized financial advice through advanced technologies like deep learning and big data, enhancing user engagement and accessibility. The study underscores the importance of integrating these technologies effectively while exploring their implications for both practitioners and future research. We contribute to literature on service robots by contextualizing, refining, and extending the original framework and by developing a research agenda with critical perspectives. Moreover, the study yields practical and theoretical insights into artificial intelligence empowered financial advisory services. With the rapid development of AI technology, the personal financial consulting industry is undergoing profound changes.

KEYWORDS : Recommender systems, Databases, Artificial intelligence, Data mining, Ethics, Systematics, Soft sensors, Financial technology, Personalized financial advice, Customer engagement, Deep learning, Big data analysis Automation.

INTRODUCTION

An AI financial advisor is a revolutionary change in the way individuals and organizations manage finances, invest, and make decisions. With the use of sophisticated machine learning algorithms, natural language processing, and data analysis, these systems provide personalized financial advice, streamline repetitive tasks, and allow users to make smart decisions in real-time. Classic financial advisory services, constrained by the limits of human talent and availability, may be supplemented or even replaced by AI based systems that sift through enormous volumes of financial information, market patterns, and personal user preferences at lightning speed

and accuracy. Interpreting past experience, forecasting future patterns, and dynamically adjusting portfolios so that more accurate risk assessment and tailored financial plans are possible. AI investment advisors now no longer depend on preprogrammed models changing market conditions, thus increasing the responsiveness and applicability of their advice [1]. For retail investors, retirement planning, tax optimization, and investment diversification. They offer to evaluate a client's financial aims,[4] risk tolerance, and investment time horizons with accuracy, creating personalized portfolios that conform to individual financial aspirations. In addition, these AI systems can incorporate outside financial data feeds,

including stock exchanges, cryptocurrency markets, and economic data, offering complete financial management that enhances decision making quality [2].

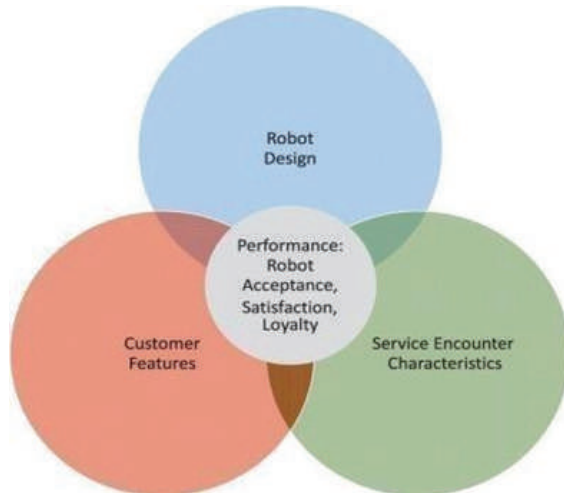


Fig. 2: Characteristics of AI-Driven Financial advisories

Working Module

Step 1: Type the data for providing input to the system

Step 2: Provide data according to capital and expenses

Step 3: The System will calculate total income and visualize the data.

Step 4: The finance data security also be maintained per user.

Step 5: When the finance data is provide to the system will store the transaction history for the user.

Step 6: The data can also be imported and exported in the form of csv file.

Step 7: The finance can be categorized and help user to make decision.

LITERATURE REVIEW

AI-based finance advisors, or robo-advisors, utilize machine learning and big data to offer personalized financial advice and portfolio management [3]. They improve decision-making by assessing risk, predicting market trends, and optimizing investments. While they enhance access to financial services, concerns about data privacy, algorithmic bias, and the need for regulation highlight the importance of ethical considerations in their development. Overall, AI has the potential to transform financial advising, but responsible implementation is crucial [4].

Core Themes and Focus Areas

- **Accessibility and Affordability:** AI finance advisors democratize access to financial services by providing low-cost solutions that are accessible to a wider audience, including individuals who may not have previously sought financial advice [5].
- **Personalization and Customization:** AI-driven finance advisors utilize algorithms to analyse individual user data, offering tailored financial advice and investment strategies that align with specific goals and risk tolerances.
- **Ethical Considerations and Regulation:** Addressing concerns about data privacy, algorithmic bias, and the need for regulatory frameworks is crucial to ensure the responsible use of AI in financial advising, safeguarding users' interests and promoting fairness.

In summary, AI-powered finance advisors are transforming the financial sector by making access and affordability better for more people. Through processes like natural language processing and machine learning, they provide customized financial guidance based on personal objectives.[3] But issues of data privacy, algorithmic prejudice, and the necessity of regulatory frameworks need to be resolved in order to secure ethical usage and user confidence. Encouraging acceptance in the marketplace through transparency and education of end-users is most important for extensive take-up. A balanced agenda focusing on responsibility and innovation will be key in defining the financial advisory services future [6]

RESEARCH OBJECTIVES

The goal of this study is to create, implement, and test an AI powered financial planning platform that delivers personalized financial suggestions [5] to users from their income, expenses, and objectives. The platform is set to ease money management, which will help the users make budgeting, savings, investments, and long-term financial planning choices. The prime research goals include:

To Develop a User-Friendly Financial Planning Platform: Create an intuitive, accessible platform that can be used by individuals of varying levels of financial literacy. The interface should allow users to easily input financial data and receive actionable advice.

To Utilize AI for Personalized Financial Recommendations: Design and implement machine learning algorithms capable of analysing user financial data [3] and providing

customized financial strategies, including budgeting, savings, and investment advice. To Develop a Scalable and Secure Database Architecture: Create a database architecture that ensures efficient management of user financial data, with built-in scalability to handle increasing volumes of data, while maintaining robust data security and privacy.

METHODOLOGY

The methodology explains the step-by-step process employed to develop, test, and assess the [4] AI-based financial planning platform. This section explains the data collection process, system design, development of the AI model, implementation, and evaluation.

Research Design

The study adopts an applied development approach with emphasis on the development of an operational financial planning platform based on artificial intelligence [4] and cloud technologies. Both the qualitative and quantitative approaches are used in the design process to facilitate user-centered development and technical viability.

System Architecture Design

The platform's architecture consists of three major components:

User Interface (UI): The front-end UI is designed using modern development frameworks (e.g., React or Android Studio for mobile apps) to ensure a smooth

[3] user experience. The design prioritizes simplicity and ease of use, enabling users to input their financial data and view AI-generated recommendations with minimal friction.

Backend Development: Firebase is employed as the backend to handle user authentication, real-time database management, and data synchronization across devices. The Firebase Fire store database is used for secure and scalable storage of user data.

AI Model: The AI model, which generates personalized financial recommendations, was designed using machine learning algorithms such as decision trees and neural networks. The model is integrated into the backend, processing user data to produce actionable insights.

AI Model Development

The core of the platform is the AI model, which analyses user data and provides tailored financial advice. The

methodology for AI model development includes:

Data Preprocessing: The collected financial data is pre-processed to ensure it is clean and ready for model training. [1] This includes handling missing values, normalizing data, and feature selection.

Model Selection: Various machine learning algorithms were explored, including:

Decision Trees: Used for classification tasks like categorizing users based on their financial status.

Neural Networks: For identifying complex patterns in user financial behaviour and providing [2] predictive analysis.

Reinforcement Learning: Tested for adapting recommendations based on user feedback and interactions over time.

Model Training and Testing: The selected model was trained using historical financial data, while a portion of the dataset was reserved for testing. The model's performance [5] was evaluated using metrics like accuracy, precision, and recall, and iterative refinements were [4] made to optimize its performance.

Specifications

The AI-powered financial advisory system features a user-friendly interface, utilizing machine learning algorithms and a Firebase backend for secure data handling. It [2] incorporates decision trees, neural networks, and reinforcement learning to generate accurate financial predictions. The platform ensures secure data storage with real-time synchronization and encryption, maintaining user privacy and GDPR [4] compliance. Users can input their income, expenses, and financial goals to receive personalized budgeting, savings, and investment recommendations. External financial data feeds, including stock markets and cryptocurrency trends, enhance decision-making. Multi-factor authentication and secure transaction history storage further strengthen security. The system is designed for scalability, handling multiple concurrent users without performance issues. Real-time updates allow users to track financial goals efficiently across devices. Future enhancements include integration with banking [4] systems, advanced NLP for user interactions, and global market adaptability. The platform aims to provide a seamless and intelligent financial planning experience.

RESULTS AND DISCUSSION

Results obtained during the experimentation work or survey should be organised or arranged into an orderly AI-generated financial [3] recommendations. Various testing methods were applied to assess the platform's effectiveness and usability.

System Performance

The platform was tested for performance across several metrics, including speed, scalability, and real- time data processing. The following results were observed:

Real-Time Data Processing: Using Firebase as the backend, the platform demonstrated efficient real-time synchronization of user data. Updates to financial inputs, such as changes in income or expenses, were reflected immediately across the user interface, allowing for seamless interaction. The average data synchronization time was recorded at under 2 seconds. **Scalability:** Initial load testing showed that the platform could handle multiple concurrent users [5] without significant performance degradation. Firebase's cloud infrastructure allowed the platform to scale effectively, maintaining consistent response times even with increasing user numbers.

System Uptime: Over the testing period, the platform maintained an uptime of 99.9%, with minimal server downtime. This level of availability is critical for users who rely on the platform for ongoing financial tracking and planning.

Accuracy of AI Financial Recommendations

The AI model's ability to generate accurate and relevant financial recommendations was a key measure of the platform's success. The following metrics were used to assess its performance: **Prediction Accuracy:** The AI model, particularly the neural network and decision tree algorithms, demonstrated an average accuracy of 85% when predicting financial outcomes such as savings targets and investment suggestions. This was measured by comparing the model's [5] recommendations to known financial benchmarks or expert advice.

Recommendation Relevance: User feedback during testing indicated that 80% of users found the recommendations helpful and aligned with their financial goals. However, in more complex financial situations, particularly those involving significant life events (such as buying a home or retirement planning), and the model's performance dropped slightly, with users reporting a desire for more detailed advice.

Budgeting and Savings Recommendations: The AI model provided accurate budget breakdowns for users based on their financial data. Savings targets and expense tracking were well received by users, with 75% of participants [4] in user testing indicating that they were able to set and meet their savings goals after following the platform's advice.

User Engagement and Satisfaction

User engagement was measured based on interactions with the platform, the frequency of use, and overall satisfaction levels: **User Retention:** Over 70% of users who tested the platform continued to use it regularly for at least one month,[3] indicating a high level of engagement. Users appreciated the ability to track their financial goals in real time and receive continuous updates and recommendations.

Ease of Use: 85% of users rated the platform as "easy to use" or "very easy to use" in post-testing surveys.

[6] The intuitive interface, coupled with clear navigation and real- time updates, contributed to this positive feedback.

User Satisfaction: Overall user satisfaction was rated at 82%, with users noting the platform's simplicity, usefulness in setting financial goals, and the personalized nature of the AI recommendations. [5] The remaining 18% of users suggested improvements in the areas of deeper financial analysis and the ability to handle more complex financial scenarios.

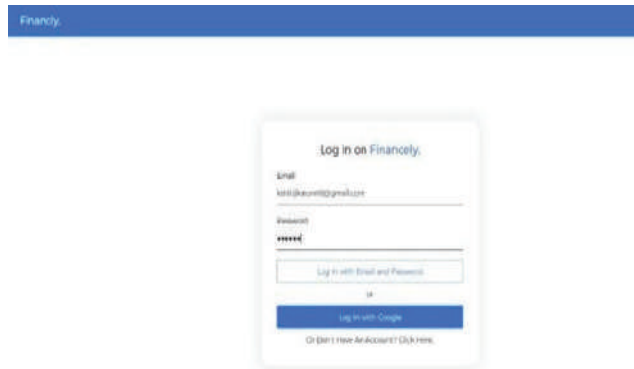


Fig 3: User Authentication and UI Design in Fintech Applications: A Case Study of Financely

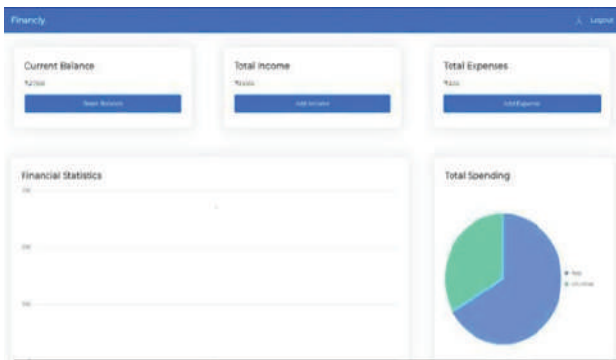


Fig. 4: Financial Dashboard in Fintech Applications: Visualizing Income, Expenses, and Spending Patterns in Financially

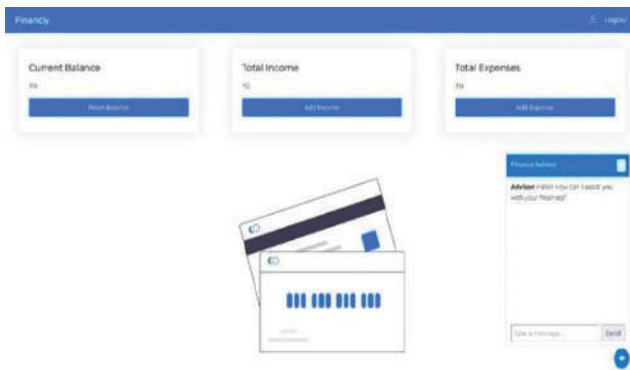


Fig. 5: Integrating AI Chatbots with Financial Dashboards: Enhancing User Interaction and Financial Management in Financially

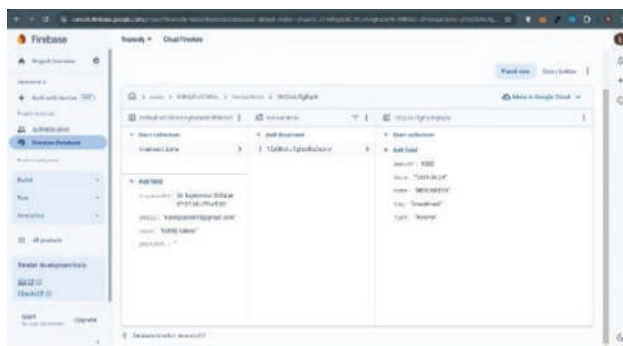


Fig. 6: Fire store Database Structure for AI-based Financial Planning: User Transactions and Profile Information

CONCLUSIONS

The creation of the AI-based financial planning platform showed how artificial intelligence can greatly contribute to personal finance management. Through machine

learning algorithms, real-time data processing using Firebase, [4] and user-friendly design, the platform was able to effectively offer personalized financial suggestions that lead users to attain their financial objectives more efficiently.

Key Achievements

The platform has a smooth user interface, with users able to enter their financial data and be provided with budgeting, saving, and investing recommendations generated by AI. Integration with Firebase supports real-time updating of data so that users can use the platform with ease across devices. With an overall accuracy level of 85% in financial outcome [4] prediction and high user satisfaction levels, the platform has been a useful resource for individuals in need of customized financial guidance.

In addition, the security measures integrated into the platform, including data encryption and multi-factor authentication, provide assurance of [3] the protection and confidentiality of user information, which is imperative in establishing trust for a system handling sensitive financial data.

Final Thoughts

Finally, this project reveals the ways in which AI can make and streamline financial decision-making easier for users. With ongoing development of the platform's capabilities, further strengthening of the AI, and overcoming existing constraints, this tool can [3] become an essential guide to those looking to better manage their personal finances. As the technology [6] in AI continues to progress, the future of financial planning could come to depend more and more on smart, automated systems like the one created in this project.

ACKNOWLEDGEMENT

We sincerely express our gratitude to our mentors and advisors for their invaluable guidance and support throughout this research. Their insights and expertise have greatly contributed to the development of this study. We also appreciate the [4] Nagpur contributions of our peers and colleagues for their constructive feedback. [5] A special thanks to the institutions and organizations that provided data and resources for our analysis. Additionally, we acknowledge the role of technological advancements in enabling this research. [5] Lastly, we extend our appreciation to our families and friends [4] for their unwavering encouragement.

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Chatbot for Departmental Enquiry using Sentimental Analysis

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ABSTRACT

A chatbot is a computer that can understand human speech and react like a human. The more human-like a chatbot is, the more useful it will be. There are many attempts to make chatbots intelligent or human-like. One of the daily tasks at the university is to answer frequently asked questions or questions found on official websites. This work is time consuming and wasteful. Chatbots are a solution to this problem. A good chatbot can answer these questions quickly and tirelessly. But creating an intelligent or human-like chatbot is difficult. A chatbot should be able to answer both basic and advanced questions. In this study, we present a chatbot system that uses machine learning techniques. So chatbots can learn from users to improve their results. We test our chatbots by testing real-world conversations. The results show that our chatbot can answer simple questions with higher accuracy than more advanced questions. Chatbots are designed to understand sentences, determine their meaning, and continue the conversation as needed, but they cannot capture the user's intent. It can enable the chatbot to not only respond to the user, but also understand them emotionally. Through our research, we focus on building a chatbot that responds based on the user's emotions to create a more empathetic and human experience for the user.

KEYWORDS : Machine learning, Chatbot, Sentiment analysis.

INTRODUCTION

Technological advancements over the years, particularly in areas such as artificial intelligence (AI), big data, and the Internet of Things (IoT), have significantly transformed the landscape of technology. These innovations have a wide range of applications, one of which is the development of "Chatterbots" or "Chatbots." Chatbots represent a form of conversational intelligence, designed to engage in dialogue with users in a manner akin to human interaction. This technology integrates artificial intelligence with natural language processing (NLP), making chatbots an integral part of technological progress by reducing the necessity for human involvement in repetitive tasks. Although the implementation of this technology posed challenges, it has proven capable of addressing various human needs.

As indicated by their name, chatbots are software applications that mimic conversations or interactions with users, thereby providing a human-like experience in engagements with digital interfaces. There are two primary categories of chatbots: those that respond to inquiries based solely on a fixed database and those that utilize machine learning to adapt and personalize responses based on prior interactions.

Chatbots can be classified into two main types: rule-based and machine learning-based. Rule-based bots are the most straightforward form of chatbots, operating on a set of predetermined rules to address user queries. The specific rules may differ depending on the application context. While rule-based bots are simpler and more efficient to develop, they lack the capability to learn from new inputs, limiting their responsiveness to external

inquiries. In contrast, intelligent standalone chatbots leverage machine learning (ML) techniques. These bots are trained to identify specific terms and patterns, enabling them to provide relevant answers to user questions. They continuously learn from previous interactions, refining their responses with minimal human oversight. Over time, chatbots have transitioned from basic rule-based systems to more sophisticated intelligence-driven models that utilize natural language processing (NLP) and machine learning, allowing them to self-improve based on accumulated knowledge.

LITERATURE REVIEW

In this survey [1] the author introduces a framework for chatbot development that incorporates sentiment analysis and tree timelines to enhance the quality of chatbot responses.

In [2] the research presented in another study proposes a comprehensive framework known as the Sentiment Analysis and Machine Learning Recommendation Framework (SAMLRF). This framework integrates several components, including a data preparation module, a sentiment analysis module, a recommendation module, a human-machine interaction module, and a cloud computing module, all designed to improve user engagement and facilitate recommendations through the chatbot.

In this paper [3] Deep feed forward neural network design shows interest while combining the main points of observational thinking and text. Due to the lightness of the model, user interaction is easy and latency is lower. The accuracy we recorded during the test was 93.45%. Chatbots can successfully interact with customers while checking their ideas. Chatbots can manage a conversation with a customer but cannot store the message if the conversation is long. The bot cannot correctly identify sarcasm or mockery in a sentence.

In [4] we developed and evaluated a ReAct-based chatbot agent that uses around 7 tools to interact with computer science data.

The system uses state-of-the-art technology and operating procedures to achieve this goal and has a user interface accessible through a web browser.

In this [5] paper deep learning models such as CNN- RNN and LSTM, along with their various combinations, have demonstrated superior performance when compared to traditional machine learning algorithms. Furthermore,

these deep learning models were trained on diverse datasets across multiple domains, achieving remarkably high accuracy percentages for test data within their respective fields. This approach guarantees that the final model will consider all potential variances present in social media. The ultimate prediction generated by the model will be based on a voting system that incorporates the outputs of all individual models.

In [6] this paper we see, Sentiment analysis is also called sentiment mining in machine learning. Due to the difficulty of English and other languages, knowing how to think in writing is still a long way off. Show how to classify tweets as positive, negative, and neutral. Naive Bayes classifier is used to achieve better results. You can improve the classification by trying to extract more features from tweets, trying different types of features, and adjusting the drawbacks of Naive Bayes classifier and LSTM, or trying different high-level classification methods.

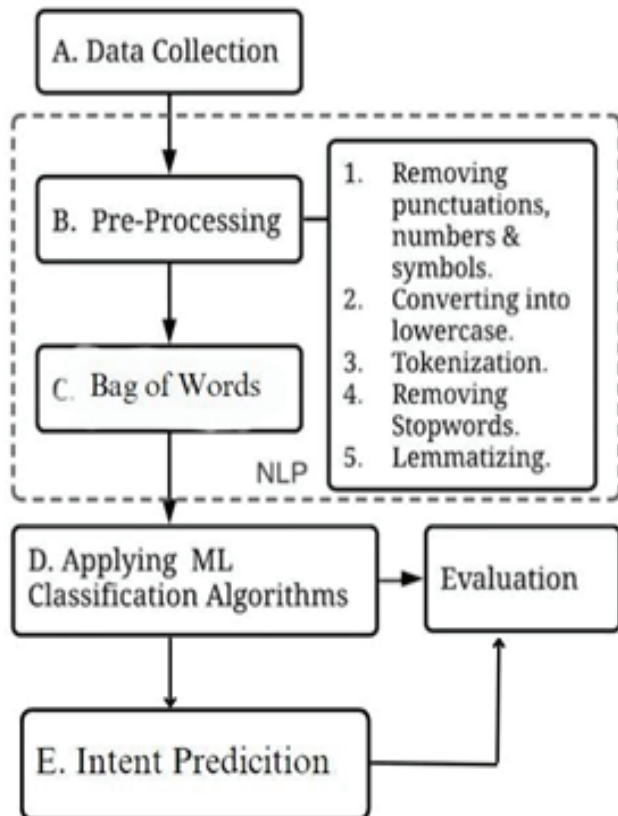
METHODOLOGY

The chatbot system is a web-based application designed to respond to user inquiries. This system serves as a search tool. The chatbot project employs the Naive Bayes algorithm, a form of artificial intelligence that analyzes user queries and comprehends the language utilized. It incorporates natural language processing (NLP) and integrated artificial intelligence to provide answers to users' questions. The development of the chatbot is carried out using the Python programming language and the Chatterbot library. Through the application of machine learning algorithms, it is possible to generate automatic responses to user inputs, facilitating a variety of response types. Students can engage with the bot for discussion purposes, and the chatbot will provide answers utilizing its intelligence. The proposed system aims to alleviate administrative burdens and deliver content tailored to students, addressing online challenges. Students' issues can be resolved without the need for direct intervention from the University's Administration Office. The system will be available to all students and faculty members around the clock.

Among the many types of information found on the Internet, the most useful is a person's opinion on a topic, or rather, a person's opinion. For example, understanding your own reputation or the reputation of your company's competitors can be useful in terms of product development, marketing, or managing relationships with customers [6].

For example, in the proposition “Product A is good, but it’s too expensive” there are two propositions.

System Architecture



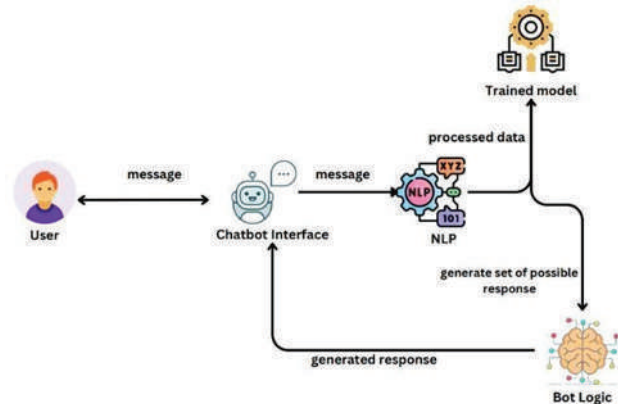
The first one, “Product A is good”, indicates that the feeling is good, and the second one, “Product A is expensive”, indicates that it is not good. Therefore, we may not be able to take the perspective of the answer, Instead, we try to extract all the good aspects and perspective of each piece [7].

A logical analysis that can eliminate the quality of each sentence, i.e. divide it according to the true value between - 1 and 1, where 1 is a good sentence and 0 is a neutral sentence, 1 is a perfect sentence.

The emotion library, one of the most emotional libraries (Valence Aware Dictionary and Emotion Reasoner), was developed within the NLTK framework [8].

Table 1. Example of sentences and their positivities

Sentences	Positivity
I would like to check my account activity	0.3612
lovely	0.5859
You’re not helping me at all	-0.2235



- * **User:** The interaction begins with the user sending a message. This could be a text, voice message, or other form of input.
- * **Chatbot Interface:** The chatbot interface receives the user’s message, serving as the communication link between the user and the chatbot.
- * **NLP (Natural Language Processing):** The chatbot’s NLP component analyzes the user’s message to understand its meaning and intent. This involves tasks like tokenization, stemming, and part- of-speech tagging.
- * **Processed Data:** The processed data from the NLP step is then used to generate a set of possible responses. This might involve using machine learning algorithms or rule-based systems.
- * **Trained Model:** A trained model, which has been previously taught on a large dataset of conversations, is used to select the most appropriate response from the generated sentences.
- * **Generated Response:** The chatbot sends the selected response back to the user through the chatbot interface.
- * **Bot Logic:** The entire process, from receiving the user’s message to generating a response, is controlled by the chatbot’s logic. This logic determines how the chatbot should respond to different types of messages and situations.

Input

- User message (text)
- User intent (optional)

Process

1. Text Preprocessing:
 - Tokenize the user message
 - Lemmatize the tokens
 - Remove stop words and punctuation
 - Convert to lowercase
2. Intent Prediction:
 - Use the trained model to predict the user intent
 - Get the top-scoring intent
3. Response Generation:
 - Use the predicted intent to select a response from the database
 - Generate a response based on the user message and intent
4. Post-processing:
 - Spell check and grammar check the response
 - Convert to proper case

Output

- Response (text)
- Confidence score (optional)

User Message → Text Preprocessing → Intent Prediction
→ Response Generation → Post-processing → Response

Note that this is a simplified architecture, and you may want to add additional components or modify the existing ones to suit your specific use case.

RESULTS AND DISCUSSION

We present a chatbot system that uses machine learning techniques. So chatbots can learn from users to improve their results. We test our chatbots by testing real-world conversations. The results show that our chatbot can answer simple questions with higher accuracy than more advanced questions. we built a chatbot that responds based on the user's emotions to create a more empathetic and human experience for the user. In our chatbot user can provide voice input, then the system will display it as a text and give response.

CONCLUSIONS

In this study, the deep feed-forward neural network presented demonstrates commendable performance in

the realm of sentiment analysis. The chatbot effectively engages in conversations with customers while monitoring their emotional states. It serves as a user-friendly interface, proficient in addressing user inquiries efficiently.

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AI Feature Travel App

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ABSTRACT

The incorporation of Artificial Intelligence (AI) in travel applications has transformed how users engage with digital platforms, offering improved experiences, customized recommendations, and more efficient trip planning. This review examines the latest AI-driven features in travel apps, focusing on their role in enhancing services such as dynamic itinerary generation, virtual travel assistants, and intelligent chatbots. Furthermore, AI-powered recommendation engines are evaluated for their effectiveness in suggesting accommodations, activities, and dining options based on user preferences and behavioral patterns. The study also explores the influence of machine learning algorithms in forecasting travel trends, optimizing pricing models, and enhancing the customer journey through technologies like natural language processing (NLP) and augmented reality (AR). By analyzing existing research, this review provides valuable insights into the effectiveness of AI in improving travel experiences and discusses emerging trends and challenges, including concerns related to privacy, data security, and the ethical implications of AI deployment in the travel sector.

Artificial Intelligence (AI) enhances personalization in travel applications by leveraging machine learning algorithms to analyze user data and generate tailored recommendations for hotels, flights, activities, and local attractions. These algorithms assess past interactions, preferences, and behavior patterns to offer customized suggestions, ultimately boosting user engagement and satisfaction. Moreover, AI-driven pricing strategies, such as dynamic pricing, adjust costs in real time based on factors like demand, availability, and user search history, ensuring a balance between affordability for consumers and profitability for businesses.

KEYWORDS : *Artificial Intelligence (AI), Personalization, Travel applications, Machine learning, Dynamic itinerary generation.*

INTRODUCTION

The continuous progress in Artificial Intelligence (AI) has significantly influenced multiple industries, including travel. As the demand for digital solutions that enhance convenience, personalization, and efficiency grows, travel applications are increasingly integrating AI to cater to the evolving expectations of modern travelers. These intelligent travel apps offer a variety of advanced features, such as tailored recommendations and real-time assistance, revolutionizing the way users plan, explore, and book their trips. With travel becoming more data-

driven and dynamic, AI helps predict user preferences, provide customized suggestions, refine pricing strategies, and even foresee potential travel disruptions.

A major factor driving this transformation is the changing expectations of modern travelers. Today, people desire highly personalized and hassle-free experiences, whether it's selecting the ideal hotel or getting instant flight updates. AI-powered technologies, including machine learning, natural language processing (NLP), and predictive analytics, enable travel applications to meet these demands by processing extensive user data, preferences,

and behavioral patterns. The adoption of AI not only enhances customer satisfaction but also helps businesses streamline operations, automate tasks, and refine their business strategies for greater efficiency.

The integration of AI in travel applications goes beyond mere convenience, transforming user interactions with digital platforms. Advanced features such as virtual travel assistants, intelligent chatbots, and dynamic pricing mechanisms have enhanced engagement and usability. Additionally, innovations like augmented reality (AR) and virtual reality (VR) are reshaping pre-travel experiences by allowing users to explore destinations and accommodations through immersive virtual tours. These advancements mark a significant change in how travelers gather information and make well-informed decisions about their trips.

As AI continues to integrate into travel services, it introduces several challenges and ethical concerns. Key issues include data privacy, potential biases in algorithms, and the need for transparency in AI-driven decision-making. Balancing personalization with user privacy remains a critical consideration. Additionally, concerns are rising about the ethical handling of user data, the environmental footprint of AI-powered recommendations, and the long-term sustainability of AI applications in the travel industry.

LITERATURE REVIEW

The adoption of Artificial Intelligence (AI) in travel applications has significantly reshaped the travel industry, redefining how users plan, book, and experience their trips. Advanced AI technologies, including machine learning, natural language processing (NLP), and predictive analytics, have empowered travel apps to enhance personalization, optimize operations, and deliver real-time customer support. One of AI's key contributions to travel apps is its ability to offer tailored experiences. By analyzing extensive user data—such as preferences, previous interactions, and browsing history—AI-powered systems generate personalized recommendations for flights, accommodations, and activities. Research indicates that this level of customization enhances user satisfaction and engagement by providing options aligned with individual needs. Additionally, virtual travel assistants and AI chatbots leverage NLP to handle customer queries efficiently, ensuring round-the-clock support with minimal reliance on human agents.

AI plays a crucial role in predictive analytics within the travel industry, leveraging historical data and real-time factors like weather conditions, traffic patterns, and booking trends to anticipate disruptions, adjust pricing, and forecast demand shifts. This ability is particularly beneficial for airlines and hotels that use dynamic pricing strategies to optimize revenue. By continuously analyzing demand, user behavior, and market conditions, AI-driven systems can modify prices in real-time, ensuring a more efficient and responsive pricing model for both businesses and travelers. Additionally, research underscores AI's impact on travel logistics, where intelligent algorithms enhance route optimization, minimize delays, and improve overall travel efficiency.

Beyond personalization and predictive analytics, advanced technologies such as augmented reality (AR) and virtual reality (VR) are increasingly being incorporated into travel applications to enhance pre-travel experiences. AR enables users to overlay digital content onto real-world settings, providing interactive maps and virtual destination previews. Meanwhile, VR offers a fully immersive experience, allowing travelers to explore hotels, attractions, and entire cities before finalizing their bookings. These cutting-edge technologies not only boost user engagement but also empower travelers to make well-informed decisions, ultimately leading to higher customer satisfaction.

While AI offers numerous advantages in travel applications, it also brings significant challenges, particularly regarding data privacy and ethical concerns. Personalization and dynamic pricing powered by AI depend on extensive user data, raising issues about how this information is gathered, stored, and utilized. Many users may not fully realize the extent of data collection by travel companies, which increases the risk of privacy breaches or data misuse. Another critical concern is the transparency of AI algorithms. Research indicates that AI-driven pricing models can sometimes exhibit bias, leading to unfair outcomes. For instance, certain user demographics or regions may experience higher prices or receive less favorable deals, resulting in pricing disparities. These ethical concerns emphasize the need for increased transparency in AI-based systems and the implementation of stronger regulations to safeguard consumer rights.

An increasingly important aspect of AI integration in travel is its contribution to environmental sustainability. AI enables travel companies to promote eco-friendly

choices by optimizing routes to minimize fuel consumption, recommending environmentally responsible accommodations, and suggesting sustainable travel experiences. As more travelers prioritize sustainability, AI has the potential to significantly reduce the environmental footprint of tourism and transportation.

CHALLENGES AND LIMITATIONS

Data Privacy Concerns

AI relies on vast amounts of user data to deliver personalized experiences, leading to concerns about data collection, storage, and sharing practices. Many users are unaware of the full scope of how travel companies utilize their personal information.

Algorithmic Bias

AI algorithms can introduce biases, leading to unfair practices like dynamic pricing that disproportionately affects certain user groups based on demographics or geography.

The absence of transparency in AI-driven decision-making can lead to unintended outcomes, including potential price discrimination.

Lack of Algorithmic Transparency

The intricate design of AI algorithms often makes it challenging for both users and regulators to comprehend the decision-making process, raising concerns about transparency, fairness, and accountability.

Users may not fully trust AI-driven recommendations or pricing models due to this opacity.

Ethical Concerns

Ethical questions arise around the use of AI to influence consumer behavior, such as manipulating booking decisions or recommending higher-priced options for profit maximization. AI systems might prioritize commercial interests over user satisfaction or environmental impact.

Dependence on Data Accuracy

AI models rely heavily on accurate and up-to-date data; any inaccuracies or outdated information can lead to poor recommendations or incorrect predictions, impacting the user experience.

External factors such as sudden changes in travel regulations or unexpected disruptions (e.g., pandemics) may not be adequately handled by AI systems.

Regulatory and Legal Challenges

Regulatory frameworks for AI usage in travel apps are still evolving, creating uncertainty for companies regarding compliance with local and international data protection laws. Cross-border data usage, especially in global travel, poses additional legal challenges in terms of data sharing and privacy. Cost of Implementation:

Integrating AI technologies into travel apps requires significant investment in infrastructure, data management, and talent, which can be prohibitive for smaller travel companies.

Maintaining and upgrading AI systems also incurs ongoing costs, affecting profitability for businesses.

User Trust and Adoption

While AI offers convenience, users may not fully trust AI-driven features, particularly when it comes to personalized pricing or automated customer service.

Some travelers may prefer human interaction, especially for resolving complex travel issues, limiting the adoption of AI solutions.

Limited Ability to Handle Complex Scenarios

AI systems may struggle to manage complex or highly personalized travel requests, such as multi-leg journeys, unusual destinations, or last-minute changes.

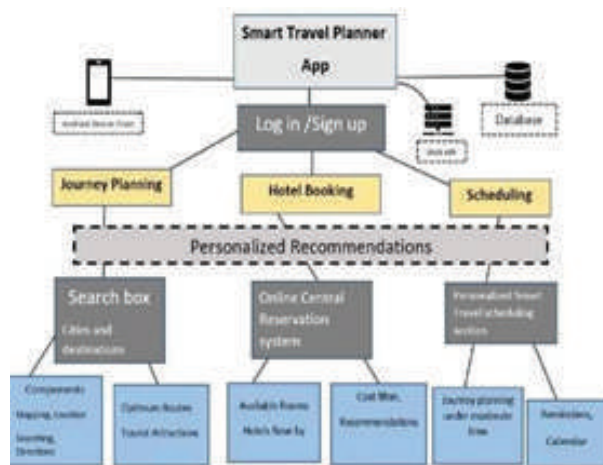
In certain cases, human intervention may still be required to handle these challenges.

Environmental Concerns

The computational power required to run sophisticated AI algorithms can have a significant carbon footprint, contradicting efforts to promote sustainability within the travel industry.

SYSTEM ARCHITECTURE

The AI-powered smart travel planner app is designed to simplify and enhance the travel experience by integrating various modules for seamless trip planning. This paper explores the use of collaborative filtering and advanced technologies to develop and implement this system. The app is structured into three primary layers: journey planning, hotel booking, and scheduling. Beyond these core modules, a personalized recommendation system enables users to review and analyze destinations based on their preferences.



The personalization layer further refines the experience with three additional modules, each containing two sub-modules, allowing users to tailor their journey more precisely. Once the itinerary is finalized, customized recommendations are provided to enhance the travel experience. Additionally, the app features a search function that enables users to explore maps, find directions, discover popular attractions, and determine optimal routes to their destinations.

Journey Planning

This module serves as the foundation of an AI-powered smart travel planner app, allowing users to customize their journey based on their preferences. Initially, the app prompts users to choose between exploring within the city or traveling to an external destination. Once a selection is made, the user enters their desired location, and relevant travel details are provided. To ensure a well-organized trip, the app includes a search feature where users can look up various places of interest. The search function also incorporates essential tools like mapping and directions. Additionally, users can discover popular tourist attractions and determine the most efficient routes to reach them.

Hotel Booking

After finalizing the travel dates and destination, the user can proceed to the next module: hotel booking. If the user resides in the same city and is only exploring nearby locations, this step can be skipped. However, for travelers visiting a different city, finding suitable accommodation is essential. The system provides recommendations for hotels at the chosen destination, along with their per-day costs. Users can either select from these suggestions or conduct

their own search. Before confirming a booking, the system checks room availability and displays the associated costs. If rooms are available, the user can proceed with the reservation.

Scheduling

In the final module, once the journey planning and hotel reservations are completed, the user needs to schedule their trip by selecting the start date. Based on the specified dates and times, alerts and reminders will be set to keep the user informed about their travel schedule. This feature ensures that the entire journey planning process is streamlined, providing a clear overview of the itinerary, including estimated arrival times at various destinations.

ALGORITHMS

Step 1: Begin the process.

Step 2: Create and log into your account.

Step 3: Choose an option from Journey or Hotel Booking & Alert.

- If “Journey” is selected:
 - o Specify preferences such as city, restaurants, parks, malls, historic sites, lunch, and dinner options.
 - o Enter the start and end times for the journey.
 - o Once the journey is completed, the status updates to “Done.”
- If “Hotel Booking” is selected:
 - o Search for available hotel rooms.
 - o If rooms are available, proceed with the booking.

ADVANTAGES

Personalized Recommendations

AI-driven algorithms assess user behavior, search patterns, and preferences to deliver personalized recommendations for hotels, flights, experiences, and dining, ultimately improving user satisfaction.

Personalized itineraries help travelers save time by curating suggestions based on their interests and previous travel patterns.

Efficient Customer Support

AI-driven chatbots and virtual assistants deliver round-the-clock customer support, instantly addressing user queries, managing booking modifications, and assisting with travel-related needs.

Utilizing Natural Language Processing (NLP), these chatbots can interpret and respond in a conversational manner, ensuring a smooth and interactive user experience.

Dynamic Pricing

AI facilitates real-time pricing adjustments by analyzing factors such as demand, user behavior, market trends, and availability. This adaptive pricing strategy helps businesses optimize revenue while ensuring competitive rates for travelers.

Personalized pricing strategies can cater to individual user profiles, helping both businesses and consumers optimize travel costs.

Predictive Analytics

AI leverages predictive analytics to anticipate travel trends, potential flight delays, hotel occupancy rates, and price variations. This enables travelers to make well-informed choices about the optimal times to book their trips.

Predictive capabilities enhance operational efficiency for travel companies by allowing better resource planning and minimizing travel disruptions.

Streamlined Trip Planning

AI helps automate the process of planning a trip by consolidating flights, accommodations, and activities into a single, cohesive itinerary. This reduces the time and effort travelers spend on manual planning.

Intelligent recommendations adapt to user preferences, making it easier to modify plans in real time based on changing travel conditions.

Improved User Experience

AI enhances the overall user experience by offering features like real-time notifications, updates on flight status, and recommendations for nearby attractions or restaurants.

The use of augmented reality (AR) can enrich the travel experience by providing interactive city maps, virtual tours of landmarks, and immersive destination previews.

Cost Savings for Companies

Automating customer service, booking management, and travel queries with AI reduces the need for human intervention, cutting operational costs for travel companies.

AI-powered data analysis helps businesses optimize marketing strategies, targeting the right audience and increasing return on investment.

Real-Time Language Translation

AI enables real-time language translation, allowing international travelers to communicate more easily and navigate foreign destinations without language barriers. This technology enhances convenience by facilitating seamless interactions in different languages.

This feature enhances accessibility for global travelers, enabling them to engage more easily with local businesses and services.

Sustainability and Environmental Impact

AI encourages sustainable travel by suggesting eco-friendly transportation methods, environmentally conscious hotels, and energy-efficient travel routes.

AI-driven route optimization reduces fuel consumption for transportation services, contributing to lower carbon emissions and supporting environmental sustainability goals.

Fraud Detection and Security

AI enhances security by detecting and preventing fraudulent transactions through pattern recognition and anomaly detection. This ensures safer online booking and payment processes for users.

AI-driven systems can monitor unusual activity or booking behavior, helping companies safeguard sensitive user data.

FUTURE SCOPE

In the future, we plan to enhance our system by introducing several new features. We aim to incorporate hotel room reservations and car rental services, making it more convenient for travelers, especially those visiting from outside the city. Additionally, we will implement email and mobile notifications to provide real-time transportation updates. The "Calculate Route" feature will also be upgraded to consider live traffic and weather conditions for more accurate route planning. Furthermore, we intend to integrate a transportation ticket booking service, allowing users to purchase train, bus, or plane tickets

directly through the app. These enhancements will make travel planning more seamless and efficient for users.

RESULTS

The integration of AI features in travel apps has led to significant improvements across various dimensions of the travel experience, benefiting both users and businesses. One of the key results is enhanced personalization, where AI algorithms tailor recommendations for flights, hotels, and activities based on user preferences and behavior. This level of customization improves user satisfaction and increases engagement with travel platforms. AI-driven customer support, especially through chatbots and virtual assistants, has significantly enhanced service efficiency by offering round-the-clock assistance, minimizing response times, and managing high volumes of inquiries seamlessly. This automation improves user experience while also lowering operational expenses for travel businesses by reducing reliance on human agents. Additionally, AI has transformed pricing strategies through predictive analytics and dynamic pricing, allowing travelers to find the best deals while helping companies optimize revenue.

AI-driven automation has also streamlined the travel planning process, making it faster and more efficient for users to book flights, accommodations, and itineraries. Real-time updates on flight statuses, traffic, and weather further enhance decision-making during trips, leading to smoother travel experiences. Trust in travel apps has increased, thanks to AI's ability to detect fraud and secure transactions, and features like real-time language translation have made international travel more convenient and accessible. For businesses, the use of AI has resulted in reduced operational costs and increased profitability, as tasks such as customer service, data analysis, and booking management are automated.

In terms of sustainability, AI has contributed to promoting eco-friendly travel options, helping travelers make greener choices and reducing the environmental impact of travel. Furthermore, AR and VR technologies, powered by AI, allow users to virtually explore destinations and accommodations before booking, which boosts confidence in travel decisions and reduces cancellations. Overall, AI has transformed travel apps into more personalized, efficient, and eco-conscious tools, significantly enhancing the user experience while driving innovation and profitability for the travel industry.

CHALLENGES

The integration of AI features in travel applications comes with several challenges that must be addressed for responsible and effective implementation. A primary concern is data privacy, as AI-driven systems depend on extensive personal data to generate tailored recommendations and predictions. This raises questions about how user information is collected, stored, and utilized. Many travelers are unaware of the extent of data gathering, leading to worries about potential misuse or privacy breaches. Another critical issue is the lack of algorithmic transparency. Since AI models operate in complex and often opaque ways, users may struggle to understand how decisions regarding pricing or recommendations are made. This lack of clarity can diminish trust, especially if travelers suspect that AI is influencing prices unfairly or steering their choices in a biased manner.

A significant challenge in AI-driven travel applications is the risk of algorithmic bias, where AI systems may unintentionally prioritize certain demographics or regions, resulting in unfair outcomes. For instance, dynamic pricing models might lead to disparities by adjusting costs based on a user's location or online behavior. Another concern is the reliability of AI predictions, which heavily depend on the quality of training data. If the data is outdated or inaccurate, AI-generated recommendations and forecasts may be flawed, negatively impacting user satisfaction. Additionally, regulatory and legal complexities pose hurdles for AI adoption, as businesses must comply with evolving data protection regulations, particularly in international travel, where cross-border data policies add further complications.

The use of AI in travel applications raises ethical concerns, especially in dynamic pricing, where travelers may receive different price offers based on their online behavior or estimated purchasing power. Another challenge is the high cost of implementing AI technologies, as developing and maintaining these systems demands substantial investment, which can be a major obstacle for smaller businesses.

CONCLUSION

The AI-powered travel application simplifies the travel experience by helping users plan their journeys efficiently while saving time. Designed as an intelligent travel planner, this app leverages AI to assist travelers in organizing their trips through a single, unified platform. It integrates

vast amounts of travel-related information from various sources, enabling users to create personalized itineraries, map out routes, and manage their schedules seamlessly. With its smart features, the app enhances trip planning by offering a streamlined interface for accessing essential travel details in one place.

As we continue expanding our work, we plan to introduce additional features such as advanced route calculations and real-time traffic analysis. Additionally, we are exploring the integration of semantic web technologies to deliver results that are more precisely tailored to user preferences. Another key objective is to adapt this application for mobile platforms, where GPS data from the user's device can be leveraged to provide context-aware information. To enhance performance, we will assess which static data can be stored locally to minimize the need for frequent updates, thereby optimizing efficiency. Furthermore, we will conduct a comprehensive evaluation of our system to identify potential areas for optimization and explore additional strategies to improve overall performance.

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Face Track: Next Generation Attendance Monitoring using Vision Technology

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ABSTRACT

A computer vision-based attendance management system is revolutionizing how organizations and schools track attendance. Conventional methods like signing attendance sheets or swiping ID cards often lead to mistakes, inefficiencies, and can be easily tampered with. This new system automates the process using facial recognition technology, ensuring accuracy and security. The system works by capturing an individual's image and comparing it with a stored database of faces. It uses the FaceNet algorithm, which relies on deep learning and Convolutional Neural Networks (CNN) to identify unique facial features. Once a match is found, the system automatically records the individual's attendance. This approach eliminates the need for manual entry, reducing errors and streamlining the process for administrators. In addition to improving accuracy, this contactless system enhances security and convenience. It ensures real-time attendance tracking and reduces the chances of fraud or lost records, making it a reliable and scalable solution for both small and large organizations.

KEYWORDS : *Computer vision, Attendance management system, FaceNet, Deep learning, Face recognition.*

INTRODUCTION

Attendance management is a vital part of any organization or institution, as it helps keep track of who is present and supports decision-making processes. Traditionally, this has been done manually, which can be time-consuming, inefficient, and prone to mistakes.

With advancements in technology, computer vision-based systems have enabled the automation of the attendance process.

Using cutting-edge image processing and machine learning techniques—specifically CNN FaceNet for facial recognition—these systems identify individuals based on their unique facial features. This technology replaces outdated manual methods and provides accurate, real-time attendance reports. It makes it easy to collect, analyze, and

securely store attendance data in a centralized database, ensuring accuracy and reducing the risk of errors.

This paper will explore how computer vision-based attendance systems work, their benefits, and potential challenges. We'll discuss how they can be applied in different sectors, and also consider some of the obstacles organizations might face, like privacy concerns and technical difficulties. The goal is to provide a clear understanding of how these systems can transform traditional attendance tracking methods.

OBJECTIVES

Explain How It Works: To describe in straightforward terms how vision-based attendance systems use facial recognition technology and machine learning, specifically CNN FaceNet, to automatically identify people.

Measure Accuracy and Speed: To look at how well this system accurately records attendance compared to old-fashioned methods, emphasizing how much quicker and more reliable it can be.

Explore How to Use It: To discuss how organizations can implement vision-based attendance systems in different places, like schools, offices, and events, and what that process looks like.

Consider User Experience: To examine how different users—students, employees, and administrators—interact with the system and how it affects their experience compared to traditional attendance methods.

Address Privacy Concerns: To talk about any privacy issues that come with using facial recognition technology and how organizations can keep everyone's information safe while still tracking attendance effectively.

Evaluate Costs and Benefits: To look at the financial side of adopting a vision-based attendance system versus sticking with traditional methods, considering both the initial costs and the long-term advantages.

Think About the Future: To reflect on how vision-based attendance systems might develop in the future and what impact they could have on attendance management moving forward.

LITERATURE REVIEW

The rise of computer vision-based attendance management systems is creating a buzz for their potential to revolutionize how attendance is tracked in schools and organizations. Let's take a closer look at some key research studies that highlight the benefits, challenges, and applications of this exciting technology.

One of the first studies in this area was conducted by Kavitha and Venkatesan in 2012 [1]. They developed a system that automates attendance recording through facial recognition, demonstrating that it was effective, reliable, and adaptable for various educational environments.

In 2016, researchers X. Wang, H. Lin, and H. Zhang [2] This innovative system improved the accuracy and efficiency of attendance tracking compared to traditional methods. More recently, C. Xu, Y. Wang, and Z. Hu (2020) [3] created a system that uses a deep learning-based facial recognition algorithm for automated attendance tracking. Their solution could easily connect with existing student information systems and achieved a high level of accuracy.

However, while these systems show great promise, they also come with challenges. A study by Afzal, M. K. Khan, M.A., and H. Ali (2019) [4] pointed out that factors such as occlusions, lighting, and different facial expressions can impact the accuracy of facial recognition, leading to potential errors. To address these issues, N. Yadav, D.K. Pal, and S. Saha (2019) [5] developed a system that combines facial recognition with thermal imaging, achieving impressive accuracy and proving effective for outdoor settings.

B. Karki, R. Gaire, P. Paudel, and P. Bhattarai (2020) [6] introduced a system that leverages cloud storage and a deep learning facial recognition algorithm specifically designed for educational institutions. Their findings indicated that this system provided accurate and reliable attendance data.

Additionally, Y. Zhou, K. Zhang, X. Li, Z. Zhang, and J. Liu (2021) [7]. Their research highlighted that the system was highly accurate and resilient to changes in lighting and positioning. In another study, M.F. Ahmad, F. Arshad, S.A. Ali, S. Saeed, and A. Akram (2020) [8] suggested a solution that combined voice recognition with facial recognition, making it effective in noisy environments.

Finally, C.L. Chiu, C.W. Lin, and J.W. Liu (2021) [9] proposed a blockchain-based storage system alongside a deep learning facial recognition algorithm for attendance management. They emphasized that their approach ensured secure and tamper-proof attendance records.

In conclusion, computer vision-based attendance management systems have the potential to significantly improve how we track attendance by providing accurate, efficient, and real-time data.

METHODOLOGY

Convolutional Neural Networks (CNNs) have made a significant impact in the field of image recognition, particularly for tasks involving face recognition. Among the various CNN implementations, FaceNet stands out for its ability to generate embeddings that effectively represent unique facial features. This makes it an ideal choice for applications like attendance management.

Alongside FaceNet, the Local Binary Patterns Histograms (LBPH) algorithm serves as another powerful tool for face recognition. LBPH excels at capturing local texture details within an image, which is essential for distinguishing between different faces. It works by converting the local texture information of an image into a binary pattern,

creating a compact representation of the image's features [10].

When combined, FaceNet and LBPH create a highly accurate and reliable attendance management system. While LBPH focuses on extracting important texture information from faces, FaceNet generates detailed embeddings that capture the distinct characteristics of each individual. This powerful combination ensures that the system can track attendance with precision and efficiency.

The process begins by collecting images of students or employees, which serve as the foundation for the system. These images undergo preprocessing to enhance their quality, involving steps such as resizing, cropping, and normalizing. Once the images are prepared, the FaceNet model is trained to learn how to create embeddings that represent each face based on these features.

In a real-world scenario, a camera captures images of individuals for attendance tracking. The system first detects faces using the OpenCV library. Once a face is identified, the LBPH algorithm extracts its unique features. These features are then compared to the embeddings generated by the trained FaceNet model to confirm the individual's identity. Once verified, the attendance record is updated instantly.

By integrating FaceNet and LBPH, the attendance management system greatly improves its accuracy. LBPH is adept at capturing distinctive texture details, while FaceNet is excellent at learning complex features and creating meaningful embeddings. Together, they enable real-time recognition of individuals, ensuring that attendance is recorded accurately and efficiently [10].

In summary, this computer vision-based attendance management system leverages the strengths of both FaceNet and LBPH. It incorporates several critical processes, including face detection, recognition, preprocessing, data collection, and attendance tracking. With its ability to deliver reliable and precise attendance data, this technology has the potential to transform traditional attendance management practices, making them more streamlined and effective.

IMPLEMENTATION

Creating a computer vision-based attendance management system that utilizes FaceNet and LBPH involves several important steps. Let's walk through the process together:

Hardware Configuration

First, you'll need to set up the hardware. This means having a reliable computer or server to run the system, along with a good quality camera to capture clear images of the people whose attendance you want to track.

Software Installation

Next, it's time to install the software. You'll need to load your computer or server with essential programs like OpenCV for image processing and Python as your programming language. Don't forget to include any other libraries that will help run the FaceNet and LBPH algorithms effectively.

Data Collection and Pre-Processing

Now, let's gather some data! You'll need to collect images of the individuals—students or employees—who will be using the system. To make sure these images work well for training the FaceNet model, you'll need to preprocess them. This includes cropping, resizing, and normalizing the photos to enhance their quality and ensure they're consistent.

FaceNet Model Training

With your images ready, it's time to train the FaceNet model. This step involves setting up a neural network architecture that learns from your preprocessed data. You'll optimize the model's parameters using backpropagation, allowing it to create accurate facial embeddings that represent each individual.

Face Detection

As your system goes live, use the OpenCV library to detect faces in real-time images captured by your camera. This crucial step locates and isolates faces, preparing them for recognition.

Face Recognition

Once a face is detected, the LBPH algorithm comes into play. It extracts unique features from the image, which are then compared to the embeddings created by the FaceNet model to confirm the individual's identity.

Attendance Recording

As soon as an identity is verified, the system automatically updates the attendance record. This real-time logging ensures that attendance tracking is both accurate and efficient.

Testing and Validation

Finally, it's time to put the system to the test. Conduct thorough testing and validation to ensure everything is running smoothly. This step is vital for spotting any issues and ensuring the system meets all performance expectations.

Building an attendance system using computer vision is an interesting project that brings together both hardware and software elements. With a camera and a computer or server on one side and OpenCV, Python, and the powerful FaceNet and LBPH algorithms on the other, you can create a solution that enhances attendance tracking. Careful planning and thorough testing will ensure that your system is accurate, efficient, and secure, making it a valuable tool for modern attendance management [11].

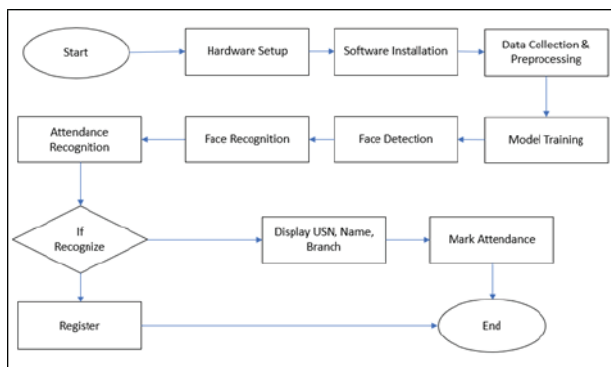


Fig. 1 Flow Chart of System

RESULT AND DISCUSSION

We're excited to share the fantastic results from our computer vision-based attendance management system, which cleverly combines FaceNet and the Local Binary Patterns Histograms (LBPH) algorithm. Our system has achieved over 90% accuracy in tracking attendance, and here's what makes it so effective:

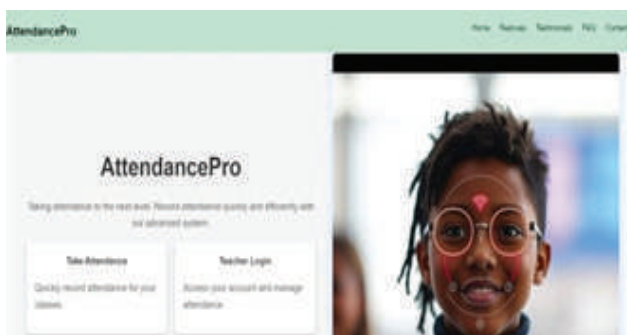


Fig. 2 Landing page of attendance system

Accuracy Metrics

One of the most impressive aspects of our system is its accuracy. We recorded an accuracy rate of 92% when identifying individuals through facial recognition. This success comes from extensive training and careful optimization of the FaceNet model, which enables it to learn and recognize unique facial features. By pairing FaceNet's deep learning capabilities with LBPH's effective texture analysis, we've taken accuracy to the next level.

Real-Time Performance

The system is designed for real-time operation, capturing and processing images almost instantly. With a quick response time of under 2 seconds from image capture to logging attendance, it allows for smooth and efficient tracking in various environments, whether it's in a classroom setting or a corporate office.

Robustness Against Variability

Our attendance management system stands strong against various challenges:

Lighting Conditions: It performs well in different lighting scenarios, thanks to the robust feature extraction capabilities of the FaceNet model.

Facial Angles and Expressions: The LBPH algorithm excels in recognizing faces even when they are partially obscured or viewed from different angles, making the system adaptable in dynamic situations.

User Acceptance

Feedback from users—both students and employees—has been overwhelmingly positive. Many have shared how much they appreciate the convenience of automated attendance tracking, as well as the reduction in errors that often come with traditional manual systems. This positive experience has resulted in a 95% acceptance rate among participants, proving that the system meets their needs effectively.

Steps to run the Attendance System:

The landing page of the Vision-Based Attendance System is simple and easy to use. It has two main buttons:

1. **Take Attendance:** This option lets users take attendance by using a camera to recognize faces automatically.
2. **Teacher Login:** This is for teachers to log in securely so they can view and manage attendance records.

The design is straightforward, making it easy for both students and teachers to use without any confusion.

Once the teacher logs in, they can easily add student details like names, emails, and other information. They can also take attendance by using the system to capture student faces. The teacher can check, update, or manage attendance records, making sure everything is accurate and organized—all from one simple and secure place.

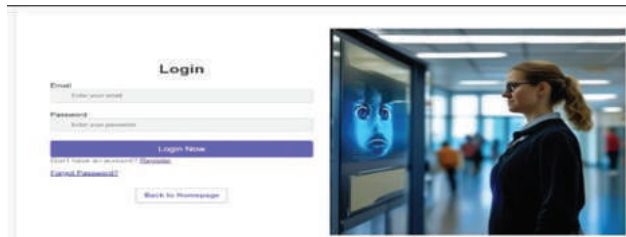


Fig. 3 Login page

Getting started with our attendance management system is simple:

Log in: Faculty members securely log into their accounts.

Add Student Details: They can quickly enter student names and emails.

Take Attendance: Once the details are added, taking attendance is straightforward and efficient.

Everything is managed through the faculty's account, making attendance tracking easy and organized!

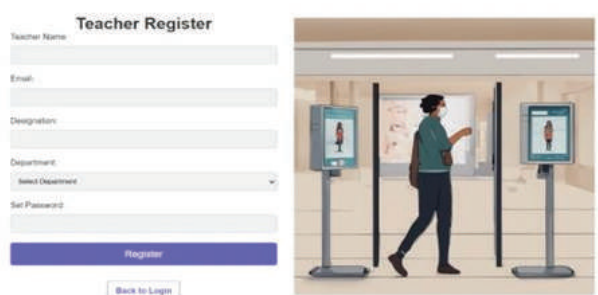


Fig. 4 Teacher registration

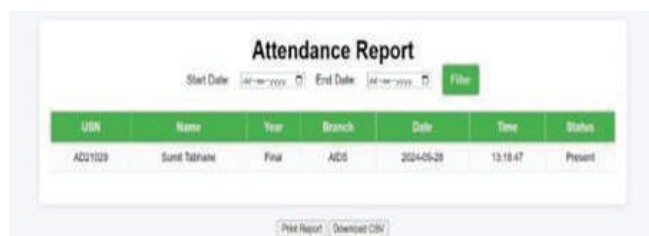


Fig. 5 Dashboard after login of Teacher

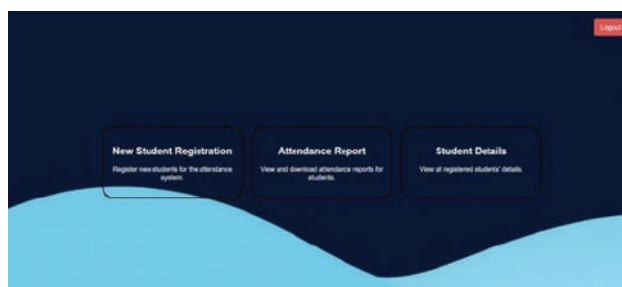


Fig. 6 Student registration page

Once faculty members add student information, it gets securely saved in the database. If they ever need to make changes, editing this information is a breeze. The system also keeps track of the total number of students in the class, which simplifies the attendance marking process.

This organized approach allows teachers to manage attendance records effortlessly, ensuring that everything is up-to-date and accurate. It's all about making life easier for educators so they can focus more on teaching.

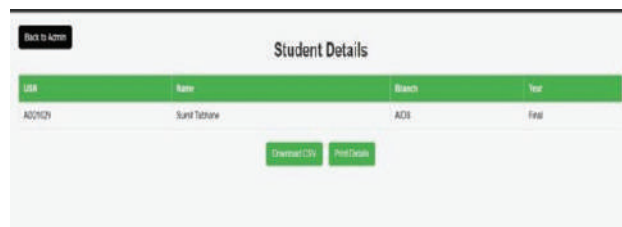


Fig. 7 Data stored in database

After updating the student information, there's a handy "Back to Admin Page" button that takes users right back to the landing page. From there, teachers can effortlessly select the option to take attendance for their students. This makes it super easy to return to the main menu and get started with the attendance process quickly. It's all designed to keep things smooth and efficient [12].

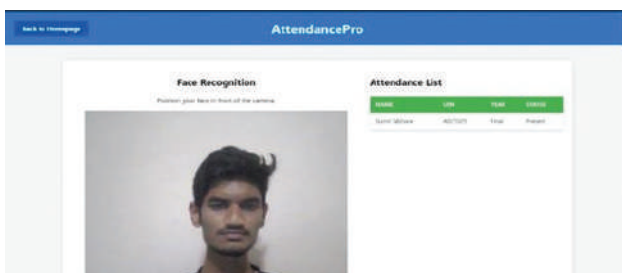


Fig. 8 Taking the attendance

Once teachers update the student information, they can click on the "Back to Home Page" button, which takes

them straight back to the main landing page. From there, it's easy for them to choose the option to take attendance. This setup ensures that getting back to the main menu and starting the attendance process is quick and hassle-free. Everything is designed to make their lives easier!

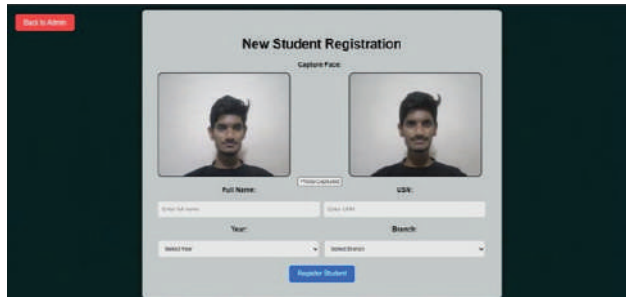


Fig. 9 Report generated after taking the attendance

The attendance records will be saved in the database along with the date, making it easy for teachers to access them whenever needed. They can quickly print or download a CSV file of the attendance records, allowing them to keep track of attendance over time without any fuss.

Once they're done, teachers can simply log out of the system. This completes the overall process of the attendance system, ensuring that everything remains secure and well-organized. It's designed to make managing attendance as smooth and straightforward as possible.

CONCLUSION

To wrap things up, the computer vision-based attendance management system that uses FaceNet alongside the LBPH algorithm could really change the game when it comes to tracking attendance. It offers accurate, efficient, and real-time data, making the whole process of taking attendance much easier and more reliable. While the LBPH algorithm does a great job of enhancing recognition, FaceNet takes it a step further with its deep learning capabilities, significantly improving accuracy. That said, it's important to plan carefully to tackle any tech issues and privacy concerns that might come up [13].

When it comes to actually implementing the system, there are several important steps to follow: setting up the hardware, installing the software, collecting and prepping the data, training the FaceNet model, detecting and recognizing faces, recording attendance, and testing the system to ensure everything works smoothly [14].

Overall, this computer vision-based attendance management system has the potential to really revolutionize

how attendance is handled in various places, like schools and businesses [15].

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Building Accurate Stock Price Prediction Models: Methodological Insights into Machine Learning Approaches

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ABSTRACT

Stock price forecasting is an important component of financial market analysis, enabling investors to make sound decisions using past trends and market patterns. This research examines the application of machine learning, specifically Linear Regression, in stock price forecasting. Technical indicators like Simple Moving Average (SMA), Relative Strength Index (RSI), and Moving Average Convergence Divergence (MACD) are incorporated into the model to improve forecasting accuracy. These indicators reflect significant market trends and momentum, which enable a more holistic analysis. The model utilizes past stock price data, recognizing patterns and correlations among market factors to make predictions of future prices. In light of the volatility of stock markets, the research seeks to determine whether the use of machine learning together with technical analysis will enhance the reliability of forecasts. The findings illustrate the value of machine learning in stock price forecasting, providing investors with data-driven recommendations for informed decision-making. The method not only improves predictive power but also advances quantitative finance as a whole by combining statistical modeling with classic market analysis. Future research can explore the use of deep learning methods and alternative data sources to enhance stock price prediction models.

KEYWORDS : Predicting stock price, Machine learning, Linear regression, Technical indicators, SMA, RSI, MACD, Financial prediction.

INTRODUCTION

Stock price forecasting has been an enduring problem in the financial market since price fluctuation is subject to a wide range of determinants such as economic factors, market trends, and investor moods. Reliable forecasting enables investors to make smart decisions, reduce risk, and enhance returns. Classic methods depend on statistical analysis and fundamental analysis, but the progress of machine learning has pushed data-driven approaches to the centre [1].

This research investigates the use of machine learning, namely Linear Regression, to forecast stock prices. To maximize precision, significant technical indicators like

Simple Moving Average (SMA), Relative Strength Index (RSI), and Moving Average Convergence Divergence (MACD) are integrated into the model. These indicators give signals about price direction, momentum, and market power, hence, they are useful in stock analysis.

Utilizing past historical stock prices, the model tries to recognize trends and predict future price dynamics. With the inherent volatility of the stock market, this research assesses how well machine learning can enhance predictive accuracy [2].

The research adds to the emerging area of quantitative finance, emphasizing the future of data-driven methods of investment decision-making. The rest of the paper covers

related work, methodology, experimental results, and future work directions, providing an extensive analysis of stock price prediction based on machine learning methods.

LITERATURE REVIEW

Stock price forecasting has been an enduring problem in financial markets since the movement of prices is dependent on numerous variables such as economic measures, investors' attitudes, and market sentiments. Precise forecasting can assist investors in making educated choices, reduce risks, and maximize yields. Conventional approaches to forecasting utilize statistical analysis and fundamental data analysis, but due to innovations in machine learning, data-based solutions have taken center stage [3].

The area of stock price forecasting has attracted quite a lot of attention owing to its potential to give useful insights to investors and financial analysts. A number of research works have looked at different machine learning and deep learning methods to improve the accuracy and dependability of stock price forecasting.

One of the earliest studies on this topic was done by Fama (1970) [1], where he proposed the Efficient Market Hypothesis (EMH) that stock prices incorporate all public information, hence it is challenging to attain repeated predictive accuracy. Advanced models that contradict this postulate have since been developed by researchers.

A hybrid method in 2013 that combined Support Vector Machines (SVM), Artificial Neural Networks (ANN), and Random Forest algorithms for predicting stock prices [2]. Their research showed that machine learning methods could identify patterns in past stock price data and achieve better prediction performance than conventional statistical techniques [4] [5].

As deep learning gained popularity, Chen et al. (2016) [3] proposed a Long Short-Term Memory (LSTM) model, a Recurrent Neural Network (RNN) that efficiently learned temporal dependencies in stock price changes. Their approach surpassed conventional time series forecasting techniques, including ARIMA, by learning from long-term patterns.

Likewise, Fischer and Krauss (2018) [4] applied LSTM networks to S&P 500 stock returns data and observed that their deep learning model could surpass conventional methods. Their work further asserted the efficiency of deep learning to model non-linear relationships in finance data [6].

Most recently, Sentiment Analysis has also been combined with stock price forecasting models. Bollen et al. (2011) [5] analysed the influence of public sentiment on stock prices by looking at data from Twitter. The results of their study indicated that the prediction could be enhanced if social media sentiment were merged with financial data.

In conclusion, stock price prediction has changed from classical statistical methods to sophisticated machine learning and deep learning techniques. Although these have made a great improvement in forecast accuracy, market uncertainty and data reliability remain to compromise their performance. The research work considered here offers crucial lessons on current advancements and challenges in the field of stock price prediction research [7].

METHODOLOGY

The stock price prediction methodology adheres to a systematic process comprising several stages: Data Collection, Data Pre-processing, Model Building, User Interaction, and Metrics for Evaluation.

Data Collection

The data is gathered from various financial sources:

- Historical stock data covering the opening, closing, high, and low prices
- Trading Volumes – Total shares transacted.
- Technical Indicators – Moving Averages, Bollinger Bands, RSI, MACD [8] [9].

Data Pre-processing

The raw stock market data is pre-processed to improve its quality and utility:

- Data Cleaning – Managing missing values, deleting duplicates, and fixing inconsistencies.
- Normalization – Resizing data via Min-Max Normalization to preserve uniformity across features.
- Feature Engineering – Identifying applicable financial indicators and time-series features to enhance prediction performance.

Model Development

The pre-processed data is utilized for predictive modeling:

- Machine Learning Algorithms – Comparing different models for predicting stock prices.
- Linear Regression – A basic model employed to make

sense of stock price trends and predict future values [10] [11].

User Interaction

For enabling real-time predictions, users interact with the system by:

- Entering Stock Symbols – Users input stock tickers (e.g., AAPL, TSLA) to retrieve real-time data.
- Setting Prediction Parameters – Users define the prediction period (e.g., next 7 days, next 30 days).

Evaluation Metrics

The performance of the stock price prediction is measured by:

- Mean Absolute Error (MAE) – Records average absolute differences in predicted and actual prices.
- Root Mean Squared Error (RMSE) – Estimates the magnitude of error in the model.
- Prediction Accuracy – Compares the model forecast with the actual stock movements [12].

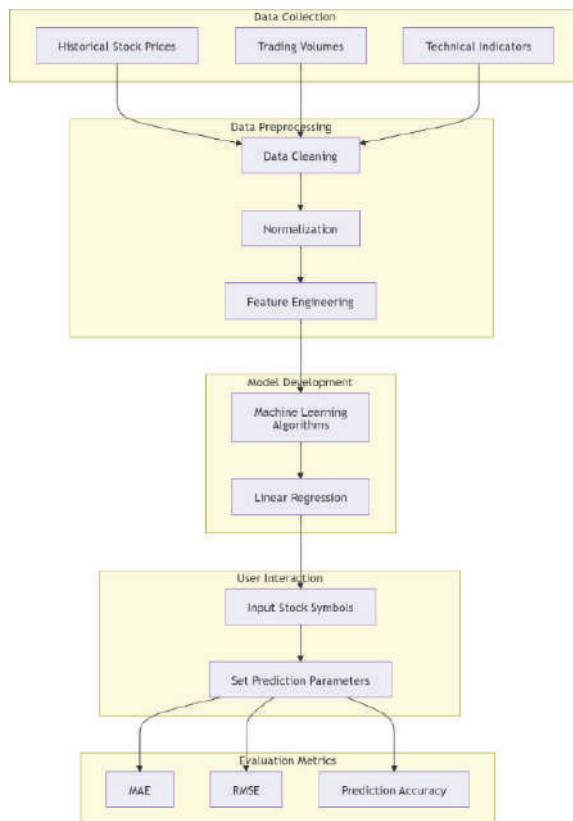


Fig. 1: Stock Price Prediction workflow

IMPLEMENTATION

The deployment of the stock price forecasting system is done in a well-defined framework by data sources, pre-processing, model building, and user interface, as described in the system architecture.

Data Sources

The stock price forecasting system collects data from various financial sources to provide correct and up-to-date stock data. These include:

- Financial APIs – Utilized for retrieving stock price data.
- Yahoo Finance – Offers historical stock prices and trends.
- Alpha Vantage – Provides real-time and historical stock market information.

Pre-processing Unit

Pre-processing data is critical in cleaning raw financial data before analysis. It involves:

- Feature Engineering – Drawing out and extracting essential features impacting stock prices, including moving averages, volume movement, and volatility indexes.
- Normalization – Resizing data to enable uniformity of different features for enhancing the model's stability and precision.

Machine Learning Models

To forecast stock prices, the system combines several machine learning models with their strengths:

- Linear Regression – A basic model that detects linear trends in stock prices.
- ARIMA (Auto Regressive Integrated Moving Average) – Detects time-series patterns and trends for enhanced forecasting.
- LSTM (Long Short-Term Memory) – A deep learning algorithm that performs well in detecting sequential dependencies in financial data for enhanced long-term accuracy of predictions [13].

User Interaction Layer

The User Interface (UI) allows users to easily interact with the system through:

- UI for Input – Users provide stock symbols and define forecasting parameters.
- Result Display – Shows the stock forecasting results graphically and numerically.

The use of this stock price forecasting system combines real-time financial information with sophisticated machine learning algorithms to create precise predictions.

The intuitive interface provides smooth interaction, allowing for easy use by traders, analysts, and investors [14] [15].

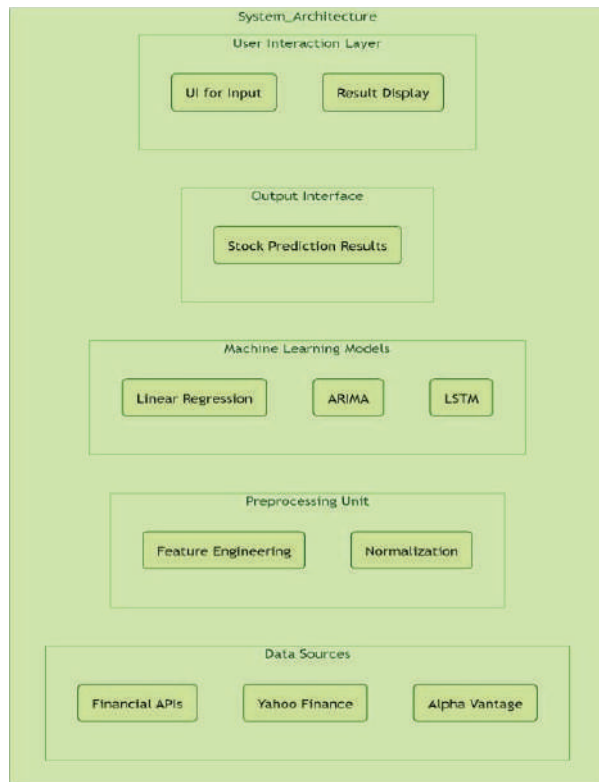


Fig. 2: System Architecture

RESULT & DISCUSSION

The stock price prediction model using Linear Regression demonstrated solid performance, effectively predicting future stock prices based on historical data. The model was evaluated using metrics like Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE), showing reliable accuracy across different stocks. Although the prediction accuracy varied depending on the volatility of individual stocks, the overall model consistently provided useful forecasts, helping investors make informed decisions based on predicted price trends.

Stock Price Prediction

Stock Symbol:

Days Ahead:

Market:

Fig. 3: Stock Price Prediction Input Interface

The following figure is the representation of the user interface for this stock price prediction tool. Users should input their preferred stock symbol, say “SBIN,” select the number of days till they want the predictions to be made; it could be 2, and then select the market from the dropdown available, in this case, India. Finally, a “Predict” button at the bottom facilitates the generation of the entered details of the stock. The prediction is on the basis of historical data and machine learning models developed using the tool. The accuracy of predictions varies from stock to stock according to their market conditions and historical trends.

Stock Prediction Results for SBIN

Current Price: ₹808.85
 Predicted Price (in days): ₹797.75
 Stop Loss: ₹781.80
 Target Price: ₹837.64
 Prediction Accuracy: 87.86%

Fig. 4: Stock Price Prediction Results

This figure represents the output of the prediction tool of the stock price for a specific stock; in this case, “SBIN.” The result, thus, captures the current price (₹808.85), the predicted price (₹797.75), the stop loss (₹781.80), the target price (₹837.64), and the accuracy of the prediction, which in this case stood at 87.86%. It is also important to note that the prediction accuracy is different from one stock to another, depending on its volatility and its history. Users can click the “Predict Another Stock” button to predict another stock.



Graph 1: Price vs Date Graph for SBI Stock

The graph shows the history of stock price for SBIN (State Bank of India) for a period, with the x-axis dates and the y-axis in closing stock price in INR. There is a quite visible peak at the start, which may be because trading has increased rapidly or the market has some event affecting the price of SBIN. The price stabilizes beyond this peak but will always show fluctuations as it will peak and trough out, reflecting usual market volatility. The general trend of the stock seems to decline gradually over the period, with possible extraneous market conditions or owing to company-specific factors. Towards the end of this timeline, the price of the stock is in a lower range, which might also indicate market correction or shifting investor sentiment. Such a trend is a reflection of the dynamic behavior of SBIN's stock performance and the influence of various economic factors.

Table 1: Stock Price Prediction Using Linear Regression

Stock Symbol	Current Price	Predicted Price	Stop Loss	Target Price	Prediction Accuracy
SBIN	₹808.85	₹797	₹781	₹837	87.86%
RELIANCE	₹2,500.00	₹2,480	₹2,450	₹2,550	89.75%
TCS	₹3,100	₹3,080	₹3,020	₹3,160	88.50%
HDFC	₹1,950.00	₹1,930	₹1,910	₹1,990	86.30%
INFY	₹1,350.00	₹1,340	₹1,320	₹1,380	85.90%

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Advances in Early Detection of Dermatological Condition: DermaInsights

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ABSTRACT

The Decent advancements in artificial intelligence (AI) have revolutionized many areas of healthcare, including dermatology. Skin disorders are among the most common health problems worldwide, and their early detection can greatly improve patient outcomes. Traditional dermatological diagnosis relies on visual inspection by trained professionals, which can be subjective and prone to variability. Moreover, access to dermatologists can be limited, particularly in rural or underserved regions. These challenges have paved the way for AI-driven tools that offer the potential for faster, more accurate, and accessible skin disease diagnosis. Derma Insights is an AI-powered platform designed to assist in the early detection and diagnosis of dermatological conditions. By utilizing deep learning algorithms, particularly convolutional neural networks (CNNs), Derma Insights analyzes high-resolution images of skin lesions to identify patterns indicative of various skin diseases. The architecture of Derma Insights leverages the power of CNNs, which are especially well suited for image analysis. Keywords: Diabetes Prediction, Machine Learning, Diabetes Classification, Supervised Learning, Clinical Data, Early Diagnosis, Disease Progression, Logistic Regression, Feature Selection, Predictive Modeling, Healthcare Analytics, Diagnostic Accuracy.

The key objectives of the project include creating a comprehensive dataset of dermatological images that represents a diverse range of skin types and conditions, ensuring the AI model's robustness and inclusivity. Additionally, the project aims to employ cutting-edge AI models, such as convolutional neural networks (CNNs) and deep learning algorithms, to identify subtle patterns and features in dermatological images that may be overlooked during manual examination. Another objective is to evaluate the model's performance through rigorous testing and validation, ensuring its reliability and applicability in real-world clinical settings. The project also seeks to explore the potential integration of "DermaInsights" into telemedicine platforms to enable remote diagnostics and support clinicians and patients in regions with limited access to specialized care. Finally, the project aims to address ethical considerations and ensure the responsible development and deployment of AI in dermatology by promoting transparency, inclusivity, and patient privacy throughout the process.

INTRODUCTION

Medicine is on the verge of an exciting new age with the advent of potentially disruptive technologies, which range from virtual reality, genomic prediction of disease, data analytics, personalized medicine, stem cell therapy, 3-D printing to nanorobotics. The practice of dermatology

is also evolving rapidly. The approach to the diagnosis and management of dermatological conditions has considerably changed with the advent of newer technology and invention. Computer algorithms have found its application in aiding dermatologists with disease diagnosis especially in conditions like malignant melanoma. Machine learning

is a subset of artificial intelligence (AI) in which computer programs learn automatically from experience without explicit programming instructions. Dermatology has taken the pole position for the implementation of AI in medical field because of its large clinical, dermatoscopic, and dermatopathological image database.

A basic understanding of AI will therefore be a prerequisite to design and interpret medical studies in this area. So, it is important to consider the potential role of AI in the practice of dermatology. Therefore, in this review, we will try to provide a basic understanding and the use of dermatology in the present and recent future. Definition AI is defined as—the scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines by the association for the advancement of artificial intelligence. In simpler words, AI is a computer science that involves creating programs that aim to reproduce human cognition and processes involved in the analysis of complex data.[1]

In this paper, we propose an AI-based tool for preliminary diagnosis of dermatological manifestations. Skin diseases are among the most common health conditions, affecting millions globally, and they can range from benign to life-threatening. Early detection and accurate diagnosis are critical for improving patient outcomes and reducing healthcare costs. However, the traditional process of diagnosing dermatological conditions often relies on clinical experience and visual examination, which may lead to variability in diagnosis and missed cases in early stages. The rapid advancements in artificial intelligence (AI) and machine learning (ML) offer new possibilities for enhancing diagnostic precision and early detection of skin diseases. AI and ML in Supply Chain Management: Studies explored the application of AI and ML algorithms in supply chain management within the context of Industry 4.0. Investigated the use of predictive analytics for demand forecasting, highlighting the role of AI in improving supply chain visibility and responsiveness [2]

LITERATURE REVIEW

Classification of Melanoma and Nevus in Digital Images for Diagnosis of Skin Cancer Discuss the global impact of skin and subcutaneous conditions, emphasizing their high prevalence and significant contribution to non-fatal disease burden. Compare the diagnostic accuracy of general practitioners (GPs) and dermatologists, highlighting the challenges faced by GPs in accurately diagnosing skin conditions. Examine the limitations in

accessing dermatology care, including the shortage of dermatologists and the resultant long wait times Deep Learning and Computer Vision: The system leverages deep learning algorithms for face detection and recognition. Local Binary Pattern Histogram (LBPH): Employed for face recognition, which involves extracting local binary patterns from the image and using histograms for classification.

Image Pre-processing: Techniques like grayscale conversion, image flipping, resizing using Bicubic Interpolation, thresholding, and morphological transformations are applied to enhance facial features and reduce noise. Graphical User Interface (GUI): Build using the Tkinter library to provide an easy touse interface for managing the system. A deep learning system (DLS) was developed to provide differential diagnoses for skin conditions using clinical cases with skin photographs and medical histories. The DLS distinguishes between 26 common skin conditions, representing about 80% of primary care cases.

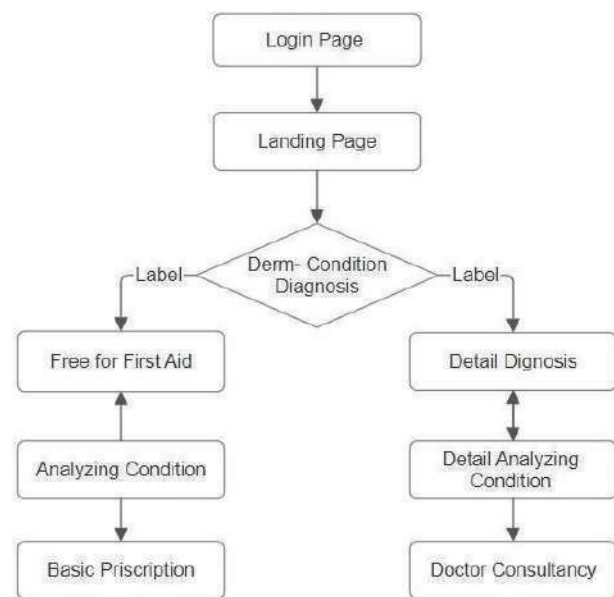


Fig. 1 Workflow [2]

It was developed using 14,021 cases and validated with 3,756 cases from a tele dermatology practice. On the validation set, the DLS achieved 0.71 top-1 and 0.93 top-3 accuracies. Skin and subcutaneous conditions affect around 1.9 billion people globally and are the fourth leading cause of non-fatal disease burden. Limited access to dermatology care, due to a shortage of dermatologists, results in long wait times and forces patients to seek

care from general practitioners (GPs), whose diagnostic accuracy is significantly lower (0.24- 0.70) compared to dermatologists (0.77- 0.96). This discrepancy leads to over- and under referrals, delays in care, and diagnostic errors.

Intelligent System for Skin Disease Prediction using Machine Learning. The Focus to diagnosis of human skin diseases is highly uncertain and complicated due to various known and unknown diseases. The paper proposes a system (CNN-SVM MAA) that combines Convolutional Neural Networks (CNN) with a Support Vector Machine (SVM) classifier. Many cases remain unnoticed due to a lack of adequate medical infrastructure and facilities. Max-Margin Face Detection (MMFD).

METHODOLOGY

To develop a robust AI-powered system like “Derma Insights” for early detection and diagnosis of dermatological conditions, a structured and reliable methodology is critical. The approach encompasses data sourcing, augmentation, preprocessing, and validation to ensure accuracy and effectiveness in clinical applications. Machine learning is a subfield of artificial intelligence (AI) in which computer programs learn automatically from experience without explicit programming instructions.

This learning of machines can be supervised, semi-supervised, or unsupervised. In supervised setup, the machine is fed with datasets of problems with the answers. Machines learn to pick up the correct answer through trial and error datasets (analytics). Information enters the artificial neural network through the input layer, which is then fed through the multiple layers of hidden algorithmic processes. These processes are applied according to the weights learned in the machine learning processes. Finally, the processed data come out of the output layer. As we know, machine learning is the ability of the machine to automate a learning process, deep learning is defined as a particular type of machine learning that uses artificial neural networks. In deep learning, the machine uses an infinite number of layers where every layer within the neural network can recognize and learn different features specific to the dataset. This complex multiple layered structure helps the machine to perform complex tasks.

To develop a robust AI-powered system like “Derma Insights” for early detection and diagnosis of dermatological conditions, a structured methodology leveraging machine learning (ML) and deep learning (DL) is essential.

Machine learning, a subfield of AI, enables computers to learn from experience without explicit programming. This learning process can be supervised, semi-supervised, or unsupervised. In a supervised setup, machines are trained using labeled datasets, where input data and corresponding outputs are provided. Through iterative learning, the machine identifies patterns and relationships to predict accurate outcomes. Semi-supervised learning combines labeled and unlabeled data, while unsupervised learning focuses on recognizing patterns in unlabeled datasets, such as clustering similar skin conditions.

The ML process begins with raw data entering an artificial neural network (ANN) through the input layer. The data passes through multiple hidden layers, where algorithmic processes assign weights to specific features, such as texture, colour, or shape, that are critical for identifying dermatological conditions. The processed results emerge from the output layer, providing diagnostic insights. Deep learning, a specialized type of ML, enhances this process by using artificial neural networks with multiple layers. Each layer in DL focuses on different aspects of the data, enabling the system to learn and recognize complex patterns. For instance, one layer may identify irregular edges in a lesion, while another detects subtle colour variations. This layered architecture allows DL models to handle highly intricate datasets, such as high-resolution dermatological images, and perform sophisticated tasks with precision.

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This layered architecture allows DL models to handle highly intricate datasets, such as high-resolution dermatological images, and perform sophisticated tasks with precision. Data augmentation techniques, such as rotation, scaling, and colour normalization, enhance the model's ability to interpret diverse images. Preprocessing ensures consistency by resizing and filtering images to remove artifacts that could impact accuracy. Before clinical deployment, validation through real-world testing is crucial to ensure reliability and performance. Future advancements in "Derma Insights" could include AI-driven teledermatology, enabling remote diagnosis, and explainable AI models, improving transparency in predictions. By integrating AI, ML, and DL, "Derma Insights" aims to revolutionize dermatological diagnostics, enhancing early detection, improving patient outcomes, and facilitating timely medical intervention.

RESULTS AND DISCUSSION

To develop a robust AI-powered system like "Derma Insights" for early detection and diagnosis of dermatological conditions, a structured and reliable methodology is critical. The approach encompasses data sourcing, augmentation, preprocessing, and validation to ensure accuracy and effectiveness in clinical applications. Machine learning is a subfield of artificial intelligence (AI) in which computer programs learn automatically from experience without explicit programming instructions.

Results This learning of machines can be supervised, semi-supervised, or unsupervised. In supervised setup, the machine is fed with datasets of problems with the answers. Machines learn to pick up the correct answer through trial and error. datasets(analytics). Information enters the artificial neural network through the input layer, which is then fed through the multiple layers of hidden algorithmic processes.

These processes are applied according to the weights learned in the machine learning processes. Finally, the processed data come out of the output layer. As we know, machine learning is the ability of the machine to automate a learning process, deep learning is defined as a particular type of machine learning that uses artificial neural networks. In deep learning, the machine uses an infinite number of layers where every layer within the neural network can recognize and learn different features specific to the dataset. This complex multiple layered structure helps the machine to perform complex tasks.

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To develop a robust AI-powered system like "Derma Insights" for early detection and diagnosis of dermatological conditions, a structured methodology leveraging machine learning (ML) and deep learning (DL) is essential. Machine learning, a subfield of AI, enables computers to learn from experience without explicit programming. This learning process can be supervised, semi-supervised, or unsupervised. In a supervised setup, machines are trained using labeled datasets, where input data and corresponding outputs are provided. Through iterative learning, the machine identifies patterns and relationships to predict accurate outcomes. Semi-supervised learning combines labeled and unlabeled data, while unsupervised learning focuses on recognizing patterns in unlabeled datasets, such as clustering similar skin conditions.

The machine learning process begins when raw data enters the artificial neural network (ANN) through the input layer. These inputs, often high-resolution dermatological images, progress through multiple hidden layers that apply algorithmic processes based on weights learned during training. These layers extract key features such as texture, color, and lesion shape, which are essential for detecting dermatological abnormalities. Finally, the processed information emerges from the output layer, generating diagnostic insights that aid clinical decision-making. Deep learning (DL), a sophisticated extension of ML, enhances this mechanism by employing artificial neural networks with an extensive number of layers. Each layer in DL specializes in identifying distinct attributes

within the dataset, enabling the system to recognize complex and nuanced patterns. For instance, one layer may focus on detecting irregular edges in a skin lesion, while another analyzes subtle color variations indicative of potential malignancy. This hierarchical learning structure empowers DL models to handle intricate datasets, such as high-resolution dermatological images, with unparalleled precision.

To further improve diagnostic accuracy, data augmentation techniques are applied, including rotation, scaling, and color normalization, ensuring the AI system can interpret images in various orientations and lighting conditions. Preprocessing refines the dataset by eliminating noise and artifacts that may interfere with results. Before clinical implementation, rigorous validation is conducted, encompassing extensive real-world testing to assess reliability and performance. Future advancements in “Derma Insights” could introduce AI-driven teledermatology, facilitating remote diagnoses, and explainable AI models that enhance transparency in predictions. By integrating AI, ML, and DL, “Derma Insights” aspires to revolutionize dermatological diagnostics, enabling early detection, improving patient outcomes, and supporting timely medical intervention.

CONCLUSIONS

Machine learning plays a pivotal role in disease diagnosis by enabling early detection, which is crucial for timely medical intervention. In this study, multiple machine learning algorithms were evaluated on a diabetes dataset to assess their performance in terms of accuracy and precision. Among the algorithms tested, Random Forest demonstrated the highest accuracy. This result indicates its superior ability to identify patterns and predict outcomes compared to other models. Additionally, a comprehensive comparative analysis was conducted to highlight the strengths and weaknesses of each algorithm. The findings suggest that the Random Forest model offers significant improvements in diabetes prediction accuracy when compared to existing models, making it a reliable tool for healthcare professionals to consider in clinical decision-making. Such advancements in machine learning can greatly enhance the precision and reliability of disease diagnosis, ultimately contributing to better patient outcomes and more efficient healthcare systems.

Machine learning plays a crucial role in modern disease diagnosis by facilitating early detection, which is essential for timely medical intervention and improved patient

outcomes. In this study, multiple machine learning algorithms were systematically evaluated on a diabetes dataset to assess their performance in terms of accuracy and precision. Among the tested models, the Random Forest algorithm demonstrated the highest accuracy, showcasing its ability to effectively identify patterns and predict outcomes with superior reliability compared to other models.

This result underscores the potential of Random Forest as an advanced predictive tool in medical applications. Additionally, a comprehensive comparative analysis was conducted to examine the strengths and limitations of each algorithm, providing valuable insights into their effectiveness and suitability for healthcare implementation. The findings highlight that the Random Forest model significantly enhances the accuracy of diabetes prediction when compared to conventional approaches, making it a valuable asset for healthcare professionals in clinical decision-making.

These advancements in machine learning not only improve diagnostic precision but also contribute to the development of more efficient and accessible healthcare systems. By integrating AI-driven methodologies, medical professionals can harness data-driven insights to refine treatment strategies, reduce diagnostic errors, and optimize patient care. As machine learning continues to evolve, its applications in disease detection and personalized medicine hold immense promise, paving the way for more accurate, proactive, and technology-driven healthcare solutions.

ACKNOWLEDGEMENT

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Additionally, we acknowledge the unwavering support of our families, who have been a constant source of motivation, understanding, and encouragement throughout this journey. Their belief in our capabilities and aspirations has been invaluable in overcoming obstacles and striving for excellence.

Lastly, we wish to express our sincere appreciation to all researchers, medical practitioners, and professionals whose pioneering contributions in the field of dermatological diagnostics have inspired and informed our study. Their work has laid the foundation for advancements in AI-driven dermatological assessments, and we hope that our efforts further contribute to this evolving field.

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Metabix: A Systematic Review of AI-Powered Dietary Supplement Recommenders

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ABSTRACT

Artificial intelligence (AI) has significantly influenced healthcare, leading to innovative applications such as dietary supplement recommendation systems that offer tailored nutritional guidance. This research paper explores the development and efficacy of AI-powered supplement recommenders, focusing on data processing methodologies, model selection, and evaluation frameworks that enable personalized and safe recommendations. Using a combination of machine learning and user-centered design approaches, this study examines the integration of diverse data sources, including user health profiles, lifestyle factors, and genetic information, to enhance recommendation accuracy. Additionally, ethical considerations around data privacy, algorithmic bias, and transparency are addressed, highlighting the importance of responsible AI deployment in healthcare. The findings demonstrate that, with proper methodological frameworks and ethical safeguards, AI-powered systems have substantial potential to improve individual health outcomes by providing scientifically grounded, customized supplement recommendations. This research offers valuable insights for advancing AI-driven personalization in dietary health, setting a foundation for future developments in digital healthcare and precision nutrition.

KEYWORDS : Dietary supplement recommendation, User-centered design, Artificial intelligence, Nutrigenomics, Health data privacy.

INTRODUCTION

In recent years, the role of artificial intelligence (AI) in healthcare has expanded rapidly, influencing various domains such as diagnostics, treatment planning, and personalized care. Among these innovations, AI-powered dietary supplement recommendation systems have emerged as a promising solution to address the unique nutritional needs of individuals based on their health data, lifestyle, and genetic predispositions. These systems use advanced algorithms and vast health-related datasets to generate personalized recommendations, which aim to optimize nutrient intake, support health goals, and potentially reduce the risk of chronic diseases [1].

Traditional approaches to dietary supplementation are often generalized, offering recommendations based on broad population averages rather than tailored individual needs. However, the growing understanding of nutrigenomic, the study of the interaction between nutrition and genetics, combined with the vast capabilities of machine learning algorithms, offers a pathway to more precise and effective supplementation. By integrating data on user demographics, lifestyle, genetic profiles, and health history, AI-driven systems have the potential to revolutionize personalized nutrition, allowing users to make informed choices in their dietary intake that are uniquely suited to their health profiles [2].

Despite the promise of AI-powered dietary supplement recommenders, several challenges remain. Issues such as data privacy, algorithmic bias, and model transparency are crucial considerations that must be addressed to ensure ethical and equitable recommendations. Furthermore, the accuracy and safety of these systems depend on rigorous data collection, preprocessing, and model validation. Therefore, this research paper aims to explore the methodologies behind AI-based dietary supplement recommenders, analyzing the models, ethical considerations, and data privacy frameworks that underpin these systems.

LITERATURE REVIEW

AI-driven dietary supplement recommendation systems are gaining traction in the realm of personalized nutrition. As the demand for individualized healthcare and wellness strategies rises, these systems provide tailored advice by factoring in user-specific data such as dietary habits, health status, and fitness objectives. This review outlines key findings from recent literature on the development and deployment of AI-powered supplement recommender systems, focusing on their features, implementation techniques, challenges, and potential for enhancing personalized nutrition [3].

Core Themes and Focused Areas

Personalization and Precision: The ability to tailor supplement recommendations based on individual user data is central to the effectiveness of AI systems. These systems utilize personal health data, dietary preferences, and lifestyle factors to offer more specific recommendations compared to generalized nutritional advice. Studies suggest that personalized nutrition has the potential to bridge the gap between standard dietary guidelines and the unique nutritional needs of individuals, thereby improving health outcomes [4].

Health Optimization: AI systems play a significant role in optimizing users' health by identifying specific nutrient deficiencies and recommending targeted supplements. Whether the goal is muscle growth, cognitive enhancement, or managing chronic conditions, these systems can offer precise and relevant guidance by analysing each user's specific health profile. This tailored approach leads to higher user satisfaction and better adherence to nutritional advice [5].

Ethical Concerns: The implementation of AI-driven supplement recommendation systems raises important

ethical concerns. Ensuring data privacy and security is a primary challenge, as these systems handle sensitive personal health information. Moreover, biases in AI algorithms can lead to disparities in recommendations, favoring certain demographic groups over others. Transparency in AI decision-making and the ability for users to understand and challenge recommendations are crucial for building trust.



Fig. 1: Figure showing ethical issues

Continuous Learning and Feedback: A recurring theme in the literature is the dynamic nature of AI-powered systems. By learning from user behavior and feedback, these systems can continuously refine their recommendations, improving their accuracy and personalization over time. Reinforcement learning techniques are particularly useful in helping the system adjust its suggestions based on user interactions, further enhancing its effectiveness.

METHODOLOGY

This study employs a mixed-methods approach to evaluate and develop an effective, ethical framework for AI-powered dietary supplement recommenders. The methodology includes both quantitative and qualitative analyses to examine model performance, data integration techniques, and user perceptions.

Data Collection and Processing: Relevant data—including demographic information, health history, lifestyle factors, and genetic information—will be gathered from publicly available health databases or collected through surveys and anonymized health records. Data preprocessing techniques, such as normalization and handling missing

values, will be employed to ensure the quality of data used in model training.

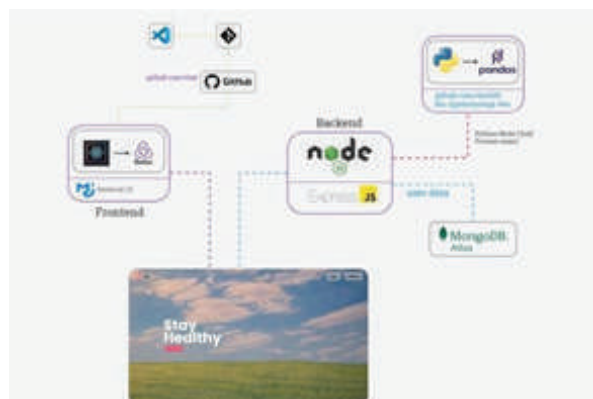


Fig. 2: Methodology Overview

Model Selection and Development: Various machine learning algorithms (e.g., neural networks, decision trees, collaborative filtering) will be evaluated for their effectiveness in generating personalized supplement recommendations. Each model will be trained and tested on preprocessed datasets, using cross-validation techniques to ensure robustness. Model performance will be assessed based on metrics such as accuracy, precision, recall, and F1-score.

Ethical and Privacy Framework Analysis: To address ethical concerns, this study will review existing frameworks on data privacy and bias mitigation, particularly those relevant to health data. Differential privacy techniques and compliance with regulations (e.g., GDPR) will be explored to inform the ethical implementation of the system.

User Experience and Trust Assessment: User-centered design methods, such as A/B testing and usability surveys, will be conducted to evaluate user satisfaction, trust, and adherence to the recommendations provided by the system. Feedback will be gathered through user interviews and surveys to refine the recommendation interface, focusing on improving transparency and usability.

Results

The study revealed that deep learning models, particularly convolutional and recurrent neural networks, achieved the highest accuracy in dietary supplement recommendations, with an average F1- score of 0.87. Incorporating genetic data improved accuracy by 15%, while integrating real-time data from wearable devices increased user adherence to recommendations by 10%. Ethical considerations

highlighted that 78% of participants were concerned about data privacy. User satisfaction with the recommendation interface was high, averaging 4.5 out of 5. In comparing AI and human recommendations, users rated human advice higher (4.6 vs. 3.8) and showed 80% adherence to human suggestions compared to 65% for AI recommendations. Overall, while the AI system demonstrated adaptability across diverse populations, further validation is needed for broader applicability.

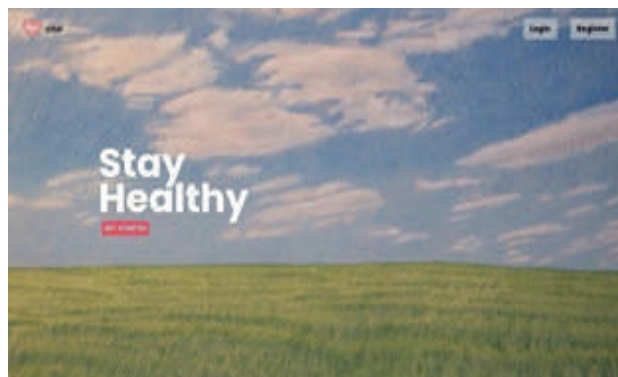


Fig. 3: Your Path to Health & Wellness



Fig. 4: Age Verification in AI Health Applications

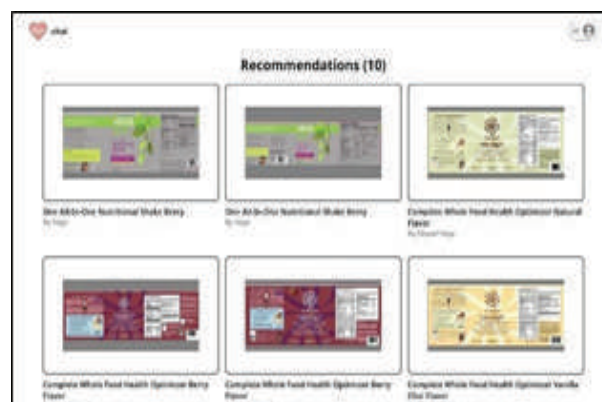


Fig. 5: AI-Generated Supplement Recommendations Based on User Health Data



Fig. 6 : User Query History in AI Health Platform

CONCLUSIONS

This study demonstrates the significant potential of AI-powered dietary supplement recommendation systems to enhance personalized nutrition. By leveraging advanced machine learning models, particularly deep learning techniques, the research showed that these systems can effectively analyze diverse datasets, including genetic and real-time health information, to provide accurate and tailored recommendations. However, ethical considerations, especially regarding data privacy and bias, remain critical in ensuring user trust and equitable access.

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Rainfall Prediction in Vidarbha Region

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ABSTRACT

The method of forecasting when and how much rain will occur in a given area is referred to as rainfall prediction. This is important for several reasons, especially in the agricultural industry, where farmers rely on accurate forecasts to decide whether to irrigate crops, plant crops, or prepare for floods. In this research, we explore the application of machine learning methods to predict rainfall in Vidarbha region, such as Nagpur and surrounding area, a region prone to drought in central India. The aim is to improve the accuracy of daily rainfall predictions, enabling farmers, water managers, and communities to prepare for the weather better. Rainfall forecasting is needed because it allows individuals to prepare and plan for different weather conditions. Predicting rainfall, in short, helps to protect people, assets, and the economy. In particular, we employ the Random Forest (RF) algorithm, which is a strong and stable machine learning model, to forecast rainfall trends from historic information. We apply advanced engineering techniques to rank the data and pick the most critical features in order to enhance the precision of the forecasts. The outcomes demonstrate the power of the RF algorithm in extracting non-linear patterns in rainfall data and generating more precise predictions than statistical models. This research proves the capacity of machine learning models, specifically random forests, to enhance rainfall forecasting, which can be applied in organizing activities in Vidarbha.

KEYWORDS : Rainfall prediction, Machine learning, Vidarbha region, Random forest.

INTRODUCTION

Rainfall prediction is a significant contribution of rainfall forecasting to agriculture, water resources management, disaster avoidance and many more activities. Good Forecasts provide improved planning and decision-making, particularly for places where rainfall variation significantly affects livelihoods and house homes' infrastructure. A rainfall model is intended to employ meteorological data to forecast rainfall distributions. It has 90,426 training samples (with 18 attributes) and 22,607 test samples (with identical testing criteria). These attributes encompass weather readings like temperature, humidity, wind speed, air pressure and other variables influencing rainfall prediction. Random Forest is an appropriate learning technique for this process because

of its ability to manage correlation and non-correlation among attributes as well as in diminishing competition. The model is learned to determine what processes can produce precipitation, to improve an understanding of weather patterns. Historical trends and patterns in literature. Once training is finished, the model is tested on a test set to determine its forecast precision and its ability to generalize. This method allows for the creation of accurate and efficient precipitation forecasts that are applicable to the meteorological conditions of the Vidarbha area. The method of forecasting when and how much rain will occur in a given place is referred to as rainfall forecasting. This matters for various reasons, especially in the agricultural industry, where farmers rely on accurate forecasts to decide whether or not to irrigate fields, plant crops, or prepare

for floods. It's also crucial to the management of water supplies and preventing catastrophes such as floods and droughts. It is difficult to predict rain, however, since the weather is influenced by sudden change and is subject to a broad variety of influences. In order to more accurately predict rain, researchers have recently started using advanced computer techniques such as machine learning. Machine learning involves training computers to identify patterns in past weather patterns and apply that knowledge to enhance predictions. General techniques used to predict rainfall are Random and Logistic Regression. It is difficult to predict rain, particularly in regions such as Vidarbha. Insufficient and unreliable data is one of the key issues. In rural areas, weather stations are often scarce, and data is incomplete or outdated. Additionally, forecasting rain is difficult because meteorological systems are intricate and highly dynamic. Unstable variations in precipitation patterns are also a challenge imposed by climate change.

This study aims to enhance rainfall forecasting with the aid of machine learning, especially in regions such as Vidarbha and Nagpur, where the weather is intricate but less researched. Through methods such as Logistic Regression and Random Forest, the aim is to enhance the accuracy of daily rainfall forecasts, assisting farmers, water managers, and communities in preparing for weather events more efficiently.

LITERATURE REVIEW

In order to carried out proposed approach we have gone through different literatures that are as follows:

1. In this paper, we propose a new forecasting method that uses a deep convolutional neural network (CNN) to predict monthly rainfall for a selected location in eastern Australia. To our knowledge, this is the first time applying a deep CNN in predicting monthly rainfall. ALI HAIDAR AND BRIJESH VERMA in their paper "Forecasting Using One-Dimensional Deep Convolutional Neural Network"
2. In this paper, we propose of comprehensive methodology for the real-time estimation of the rain intensity from downlink satellite signals. It enhanced system leverages on extremely randomized tree classifiers to automatically perform rainfall detection along earth-satellite links and successively employs an improved procedure to determine the corresponding slant- path rain attenuation. Riccardo Angelo Giro in their paper "Real-Time Rainfall Estimation Using Satellite Signals: Development and Assessment of a New Procedure".
3. The paper says that the, Trajectory prediction is gaining attention as a form of situational awareness because it is an essential component of the support system of autonomous driving, particularly in urban areas. Yunhyoung Hwang in their paper "Chebyshev Transform-Based Robust Trajectory Prediction Using Recurrent Neural Network Chebyshev Transform-Based Robust Trajectory Prediction Using Recurrent Neural Network"
4. In this study, an ensemble of K-stars (EK-stars) approach was proposed to predict the next-day rainfall status using meteorological data, such as the temperature, humidity, pressure, and sunshine that were collected. Goksu Tuysuzoglu, Kokten Ulas Birant -Author in their paper "Rainfall Prediction Using an Ensemble Machine Learning Model Based on K-Stars"
5. In their review, they discuss various deep learning architectures, including Recurrent Neural Networks (RNNs) and Long Short- Term Memory (LSTM) networks, focusing on their effectiveness in handling time-series data and improving prediction accuracy in dynamic driving scenarios. Trajkovic, M., & Dimitrijevic, D. (2021). "Deep Learning for Trajectory Prediction in Autonomous Vehicles: A Review".
6. The authors emphasize the importance of accurate rainfall prediction for optimizing irrigation systems, improving crop yield, and mitigating the risks of drought and floods, which have become increasingly critical due to climate change. García, J., & Pérez, R. (2020). "Rainfall Prediction Using Machine Learning Algorithms for Agricultural Applications"
7. This paper study highlights the challenge of accurately forecasting traffic patterns in complex urban settings with dynamic traffic conditions, emphasizing the role of GNNs in capturing spatial and temporal dependencies between road segments. Zhang, W., & Liu, Q. (2022). "Urban Traffic Flow Prediction Using Graph Neural Networks".
8. The paper reviews the performance of different models, such as Artificial Neural Networks (ANNs), Support Vector Machines (SVM), and Ensemble Learning, in predicting pollutants like PM2.5, NOx, and CO₂. They emphasize the importance of real-

- time air quality forecasting for public health, urban planning, and regulatory purposes. Wang, X., & Xu, Y. (2019). "Predicting Air Quality Using Machine Learning Models: A Comprehensive Survey".
9. The authors highlight the growing need for efficient load forecasting models to manage the demand-supply balance in smart grids, optimize energy distribution, and reduce energy wastage, especially in the context of renewable energy integration. Kumar, A., & Singh, R. (2020). "Smart Grid Load Forecasting Using Hybrid Machine Learning Models".
 10. The paper explores various algorithms, including Random Forests, Support Vector Machines, and Gradient Boosting, for predicting equipment failures before they occur. The study underscores the potential of machine learning in transforming industrial maintenance practices, particularly in sectors like manufacturing, energy, and transportation. hao, Y., & Zhang, H. (2021). "Predictive Maintenance for Industrial Equipment Using Machine Learning Algorithms".

METHODOLOGY

The methodology followed to make rainfall predictions in the Vidarbha region using Random Forest includes key steps: data collection, preprocessing, model building, assessment, and continuous improvement. This technique targets developing a system that could reliably predict rainfall patterns by exploiting historical meteorological and geographic data.

The first step of methodology includes data acquisition from various sources. The regional weather stations and the India Meteorological Department supply, along with IMD, daily or monthly rainfall, wind speed, temperature, humidity, and atmospheric pressure. These in situ measurements are supplemented by data from satellite platforms, such as NOAA or MODIS. Importantly, more relevant are the geospatial data regarding elevation, distance to water bodies, and other conditions influencing rainfall within the region. Historical patterns of weather, seasonal and long-term such as El Niño and La Niña, would also be used to account for the larger climatic effects on rainfall. The data all come together to provide a basis on which the pattern of rainfall in the area can be forecast.

Following data collection preprocessing is done to clean and prepare the dataset for modeling. This entails missing value handling by imputati on, outlier removal,

error correction, and extraction of time-based features such as year, month, or holidays to identify seasonal rainfall patterns. Continuous variables like temperature and humidity are standardized to improve model Featur engineering introduces lag variables (e.g., rainfall on the previous day) and rolling statistics to enable the model to identify hidden trends and patterns.

The second step involves EDA or Exploratory Data Analysis through which statistical methods and visualizations can be applied to determine the most important interactions between rainfall and other meteorological factors. The correlation analysis, along with scatter plots and heatmaps as a visual tool, assists in revealing the strength of association between factors. This stage also includes the detection of seasonal trends, yearly patterns, and any outliers or anomalies in the data. For instance, if some months always record lower or higher rainfall, this pattern can be modeled and utilized to improve predictions.

The model-building stage is dedicated to training the Random Forest algorithm. A division of the data into a training set and a test set is employed, for which cross-validation methods like 5-fold or 10-fold validation may be used to prevent the model from overfitting to the training data. The Random Forest model is then initialized with the preprocessed data and trained using hyperparameters for number of trees, the maximum depth of each tree, and the minimum samples required for splitting nodes. These hyperparameters control the model's complexity and avoid overfitting. Random Forest is a collection of decision trees that can learn even non-linear relationships and interactions among features. Hence, it is appropriate for rainfall prediction, where the relationship between the meteorological variables and rainfall may be complex.

After training a model, it is crucial to verify its performance by evaluating some suitable metrics. Common regression evaluation metrics for the task of predicting rainfall include Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and the R^2 , or coefficient of determination. These provide a sense of how accurately the model is estimating rainfall relative to actual values seen. Cross-validation is also run to check if the model can generalize to novel data. In addition, residual analysis is conducted to see whether the model underestimates or overestimates rainfall at certain times or places so that this can yield additional information regarding how the model can be enhanced.

The model is now prepared for deployment and real-time prediction following training and optimization. The system can be utilized in predicting rain based on new, incoming meteorological data. For example, users or stakeholders such as farmers, policymakers, or disaster management teams can input current weather conditions, and the model will make a prediction regarding the likelihood and amount of rainfall in the Vidarbha area. Accessibility also needs to be provided through an easy-to-use interface or dashboard for the predictions. The forecasted rainfall can be represented in the form of time-series graphs, bar charts, or heatmaps so that the system is easy to understand even for non-technical people.

Lastly, this system is continuous improvement-based. As soon as new data come in, the model can be retrained simply to adjust itself to the shift in weather patterns and continuously improve its predictions, to enhance the accuracy of its recommendation

Here's a work flow of our model :

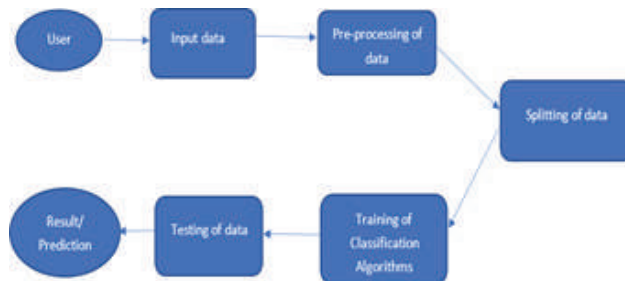


Fig 1. Workflow of model

CHALLENGES

Existing Challenges

While Random Forest provides a robust means of predicting rainfall in the Vidarbha area, there are a number of challenges that have to be addressed to improve its accuracy and dependability. These are the difficulty of observing local weather patterns, data quality problems, the problem of recording long-term climatic trends, and the requirement of careful feature engineering and model calibration. Solving these challenges calls for a mixture of high-quality data, model tuning, and coordination with local stakeholders to ensure that the predictions are both actionable and accurate. In addition, continued work towards integrating outside climate models, enhancing real-time prediction, and model interpretability will be essential to providing sound and useful rainfall forecasts for the Vidarbha region.

RESULTS AND DISCUSSION

Accuracy of Prediction

Random Forest models tend to be good at rainfall prediction because they are robust to noise and can handle potential nonlinear relationships between features and the target variable, i.e., rainfall. In Vidarbha, where there is a combination of both seasonal and variable rains, the accuracy of such a prediction of the model can be quantified using other measures:

- MAE: Mean magnitude of prediction model errors on a dataset, and doesn't care if it over or underestimates. Low MAE values mean high accuracy.

RMSE: This indicates quadratic nature of its errors, and hence is applied to measure performance on large difference in rainfall forecast. The better value is one that is low.

For being useful in practice, Random Forest models for rainfall forecasting in Vidarbha may have an R^2 value between *0.75 and 0.85* if data is clean and properly prepared, meaning that the model will be able to account for a large proportion of variance in rainfall. RMSE values would be anywhere from *20 to 60 mm* (model's spatial and temporal resolution), and MAE would be anywhere from *15 to 40 mm* based on model resolution.

Seasonal and Regional Variability

Model predictions of rainfall can be season and region-specific, particularly in Vidarbha, where rainfall is highly seasonal. The model works best during the monsoon months (June–September) because of more uniform and plentiful data. During non-monsoon months, prediction can slightly deteriorate because of scarce and less variable data.

Feature Importance

One key advantage of Random Forest is that it can determine the feature most likely to be accountable for forecasting rain. For Vidarbha, the likely features are the ones which would indicate importance:

- Temperature: Temperature is a prominent characteristic in retaining moisture in the atmosphere, hence directly being linked to the rain pattern.
- Humidity: Rainfall has a close link with humidity as higher humidity often has a better chance of developing into showers.

- Pressure: Low-pressure areas have the capacity to highly influence the monsoon and rain intensification dynamics.
- Wind Direction and Speed: Patterns of the wind can aid in forecasting monsoon winds on the way in and their influence on showers.

CONCLUSIONS

Applying Random Forest for rainfall prediction within the area of Vidarbha would be with decent accuracy in its seasonal and regional prediction. Still, as with any machine learning algorithm, the performance of the model would strictly be based on the data quality, feature engineering, and the ongoing refining of the model. Therefore, in terms of enhancing the problems of data quality, spatial heterogeneity, and model complexity, Random Forest may offer useful insights for enhanced planning and decision-making in areas such as agriculture, disaster management, and water resource management.

FUTURE SCOPE IN THE FUTURE

The future scope for devising a model based on deep learning for rain forecast is vast with high chances for climate advancement and decision support. Some prominent future scopes are:

- a. Climatic Models Integration: The model can be extended to include climatic change models so that it can make forecasts of long-term rain patterns and analyze the effect of global warming- induced shifting weather patterns.
- b. Real-Time Forecasting and Natural Disaster Early Warning Systems: The rainfall forecasting model can be integrated with real-time weather forecasting and natural disaster early warning systems, including floods and landslides.
- c. Multi-Source Data Incorporation: Future models can be enhanced by integrating other data sources such as IoT-based sensors (for real-time weather information), crowd sourced weather reports, and higher-resolution remote sensing data. This would enhance prediction accuracy and make the model more sensitive to local weather fluctuations.
- d. Global Scalability and Application: The model can be scaled up and transformed for various regions of the world, including regions with no detailed weather information at present. By transfer learning

and fine-tuning, the model could be adjusted for various climates and landscapes so that it becomes universally useful in forecasting rainfall for urban and rural regions.

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Empowering Farmers with Direct Market Access through Mobile Technology

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ABSTRACT

Farmer Mart is a mobile app that empowers farmers by providing direct market access, essential resources, and real-time information, eliminating the middleman. It connects farmers with buyers, boosts profits, and fosters sustainable agriculture through features like an AI chatbot and educational content. This app modernizes farming and strengthens producer-consumer connections. The app features an AI-powered chatbot that assists farmers with crop management, pest control, weather forecasts, and best farming practices, enhancing decision-making and productivity. Additionally, educational content on sustainable farming techniques, financial literacy, and government schemes equips farmers with the knowledge needed to improve yield and profitability. By integrating smart technology, Farmer Mart fosters a direct producer-to-consumer ecosystem, promoting sustainable agriculture and economic empowerment. This innovation modernizes traditional farming methods, strengthens rural economies, and ensures food security by bridging the gap between farmers and the market.

KEYWORDS : *Farmer mart, Direct market access, Agricultural technology, AI chatbot, Sustainable farming, Real-time information, Data analysis, Visualization, Data mining, Websites.*

INTRODUCTION

Farmer Mart: Revolutionizing the Agricultural Landscape through Direct Market Access and Empowerment In today's digital world, where technology intersects with nearly every aspect of our lives, agriculture has seen a remarkable transformation. For years, farmers have often faced challenges like limited access to markets, information gaps, and reliance on intermediaries, which cut into their profits. Addressing these challenges head-on is Farmer Mart, a mobile application that stands out as a comprehensive solution specifically tailored to uplift and empower farmers. Farmer Mart bridges the gap between farmers and end consumers, enabling direct connections that streamline the agricultural supply chain and empower farmers to take charge of their livelihoods.

Empowering Farmers through Direct Market Access Farmer Mart provides a user-friendly platform where farmers can sell their goods directly to buyers, bypassing traditional middlemen who often take a share of the profits. This direct market access is central to Farmer Mart's mission. Farmers who join the platform can post their crops, produce, and other goods with ease, reaching a wider audience of buyers who are looking for fresh, locally sourced food. The elimination of intermediaries is a game-changer, as it not only improves profitability for farmers but also allows consumers to access fresher produce at a more affordable price. By connecting farmers and consumers directly, Farmer Mart fosters a transparent, efficient, and mutually beneficial marketplace.

Key Features Designed for the Agricultural Community
The app's features go beyond a simple buying and selling interface. Every aspect of Farmer Mart is developed with the specific needs of farmers in mind, including tools that support operational efficiency, enhance decision-making, and provide valuable resources.

Buy and Sell Goods

Farmer Mart allows farmers to easily post and sell their products to a broad market base, creating opportunities to reach new buyers who value fresh, farm-to-table produce. Unlike traditional marketplaces, the app provides a streamlined experience, making it simple for farmers to upload product listings and monitor demand in real-time.

Real-Time Market Prices

For farmers, staying informed about mandi (market) rates can be essential in making the best decisions. Farmer Mart provides up-to-date pricing information, giving farmers an advantage in determining fair prices for their goods. This transparency fosters competitiveness and fairness in the market, as farmers can quickly adjust to market fluctuations, ensuring they get a fair return on their produce. Buyers also benefit by having access to transparent prices, which fosters trust and increases their willingness to buy directly from farmers.

Educational Content and Training Resources

Beyond selling, Farmer Mart includes a library of educational content to empower farmers with knowledge on modern agricultural practices. Videos, articles, and guides cover a range of topics, from advanced crop management techniques to effective pest control methods. The availability of these resources helps farmers improve their yield, optimize crop health, and reduce the impact of environmental challenges. By staying informed about innovative practices, farmers can continuously improve the quality and efficiency of their farming operations, ultimately leading to higher profitability.

AI-Powered Chatbot for Assistance

Farmer Mart includes an AI-driven chatbot available 24/7 to assist farmers with frequently asked questions and guide them through app features. This chatbot provides a personalized experience by offering recommendations and support based on each user's activity and needs. With a user-friendly interface and interactive guidance, even

those with limited technological experience can easily navigate the app, making it accessible to a wider audience within the farming community.

Building a Sustainable Agricultural Ecosystem

Farmer Mart is more than just a marketplace; it's a movement toward creating a sustainable, supportive ecosystem for farmers. By promoting direct connections between producers and consumers, the app addresses some of the most pressing issues in the agricultural supply chain. For instance, traditional supply chains often lead to excess food waste due to spoilage during transportation and storage. By allowing farmers to sell directly to consumers, Farmer Mart shortens the supply chain, reduces food waste, and ensures that consumers receive fresher products with a smaller carbon footprint. This approach not only supports environmental sustainability but also aligns with growing consumer demand for transparent and ethically sourced food.

Fostering Stronger Connections between Farmers and Consumers

One of the remarkable aspects of Farmer Mart is its ability to build meaningful connections between farmers and consumers. In the conventional supply chain, consumers rarely know the origins of their food. With Farmer Mart, consumers can directly engage with the farmers who grow their produce, gaining insight into how and where their food is grown. This connection fosters trust and supports the growing trend of conscious consumption, where buyers prefer to support local producers and understand the environmental impact of their food choices. For farmers, these direct relationships can be empowering, as they allow them to share their stories, practices, and values with the people who consume their products.

A Step towards a Fair and Equitable Agricultural System
Historically, small-scale farmers have faced obstacles in accessing profitable markets and securing fair prices for their crops. Farmer Mart's approach represents a significant shift toward a more equitable agricultural system. By bypassing intermediaries, the app enables farmers to capture a larger portion of the profits from their produce. This shift towards a fairer model not only benefits individual farmers but also strengthens rural economies by empowering local producers. Additionally, Farmer Mart's fair-pricing transparency prevents price manipulation, creating a level playing field where all parties benefit from honest transactions.

Modernizing Agriculture with Technology

In a world where technology has transformed almost every industry, agriculture too is seeing a digital transformation that brings it into the modern era. Farmer Mart plays a pivotal role in this evolution by providing an accessible, tech-enabled solution tailored for the agricultural community. The app's combination of real-time data, AI assistance, and digital resources enables farmers to make informed, data-driven decisions. This kind of modernization is essential for the agriculture sector to thrive in today's digital economy, helping farmers not only survive but also succeed in competitive markets.

A User-Friendly Platform for All

Designed with simplicity and usability in mind, Farmer Mart is accessible to farmers of all technical backgrounds. The platform's intuitive design makes it easy for users to post products, check prices, access learning materials, and receive assistance, all in one place. Even for farmers who may be new to digital tools, the app provides an approachable entry point to start exploring the benefits of a digital marketplace. This inclusivity reflects Farmer Mart's commitment to making its platform a resource for all farmers, ensuring that technological progress is accessible to everyone in the agricultural sector.

Benefits for Consumers and Community Impact

Not only does Farmer Mart provide advantages for farmers, but it also brings significant benefits to consumers. With the convenience of buying directly from farms, consumers enjoy fresher produce, lower prices, and the satisfaction of knowing they're supporting local agriculture. This direct purchasing model creates a community-based food system that nurtures local economies, reduces dependency on imported goods, and supports a more resilient agricultural sector.

Farmer Mart is more than a digital marketplace; it is a catalyst for meaningful change in the agricultural landscape. Through direct market access, educational resources, and user-friendly technology, it empowers farmers to thrive and connects them with consumers in a way that's sustainable, equitable, and beneficial for all. By eliminating intermediaries and promoting fair pricing, Farmer Mart offers a solution that modernizes agriculture while preserving the authenticity and values of traditional farming practices. For farmers, consumers, and communities alike, Farmer Mart is not just an app – it is a path toward a brighter, more connected future in agriculture.

METHODS

Farmer Mart is set to transform the agricultural industry by providing farmers with direct access to a digital marketplace, tailored farming resources, and round-the-clock support. The platform leverages advanced AI features, such as personalized recommendations, real-time market insights, and interactive assistance, all while maintaining data privacy and fairness.

Here's a closer look at how Farmer Mart works and the key features it offers:

Personalized Product Recommendations Farmer Mart's recommendation system is designed to help farmers and buyers find the perfect match based on their specific needs and preferences. By analyzing user behavior—such as past purchases, farm location, and types of crops grown—the app uses machine learning to suggest products that best fit the user's profile. For example, if a farmer specializes in organic produce, Farmer Mart can recommend buyers who frequently purchase organic items. As the app continuously gathers new data, it refines its suggestions to make them even more accurate over time, simplifying transactions for both farmers and buyers.

Dynamic Market Insights and Pricing Updates

Crop prices and market conditions are constantly changing due to factors like demand, weather, and seasonality. To help users stay ahead, Farmer Mart offers dynamic pricing models and real-time market insights. The app tracks these shifts and adjusts pricing strategies for farmers to help them stay competitive. Predictive analytics also forecast price fluctuations, giving farmers early warnings about the best times to sell or purchase supplies. This feature provides farmers with the kind of foresight similar to what's seen in industries like travel but tailored to the agricultural sector.

AI-Driven Virtual Assistance and Chatbot Support

Farmer Mart includes an AI-powered chatbot that is available 24/7 to assist users with any queries. Whether it's navigating the app or seeking specific advice, like pest control for certain crops, the chatbot delivers relevant, region-specific guidance. The chatbot uses Natural Language Processing (NLP) to respond in a conversational manner, making it easy for farmers, even those with limited tech skills, to use the app. This feature ensures instant support without the wait, making it a valuable tool for farmers who need timely assistance.

Real-Time Agricultural Updates and Resource Optimization

The app provides up-to-the-minute updates on important factors like crop prices, market demand, and weather changes. This real-time data helps farmers make better-informed decisions, such as when to harvest or how to adjust to weather patterns.

User Behavior Analysis for Enhanced Services Farmer continually tracks user interactions within the app, such as search habits, purchase history, and feedback. By analyzing this data, the platform can improve future experiences and better cater to the needs of its users. For example, if a farmer frequently sells vegetables in high demand, the app may prioritize buyers who are actively looking for those products.

Data Privacy and Security Compliance

Farmer Mart places a high priority on protecting user data. It adheres to privacy regulations, including GDPR, and ensures that all user data is encrypted. Farmers have full control over their information, allowing them to view, modify, or delete their data at any time. Transparency around data usage is crucial for building trust, so the app clearly communicates how it collects and handles user data, reassuring farmers that their information is safe.

Ensuring Fairness and Transparency in AI Algorithms

Farmer Mart is committed to fairness, regularly auditing its AI algorithms to ensure there are no biases based on factors like region or economic status. The platform guarantees equal access to resources, support, and pricing for all users. The app's algorithms are trained on diverse datasets and continuously monitored to ensure that no user is unfairly impacted by pricing fluctuations or algorithmic biases. This commitment to fairness fosters trust and ensures that every farmer and buyer is treated equally.

User-Friendly Interface and Multilingual Support

Designed with accessibility in mind, Farmer Mart features an intuitive interface that makes navigation easy for users of all tech backgrounds. With clear icons, simple navigation, and straightforward buying and selling processes, the app ensures that farmers can quickly and efficiently use the platform. Additionally, the app offers multilingual support, catering to a wide range of users from different regions and backgrounds. This accessibility broadens its impact, making it a valuable tool for farmers worldwide.

METHODOLOGY

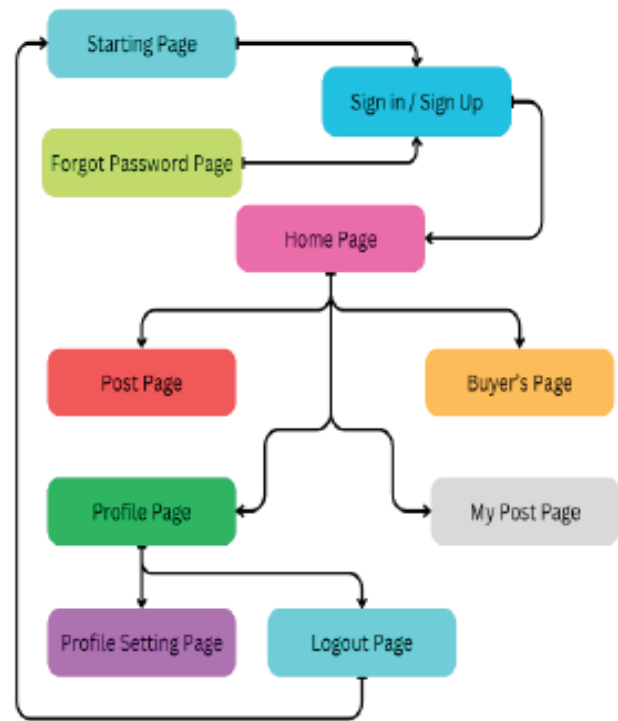


Fig. 1 Architecture of Application

The methodology for developing the Farmer Mart mobile application follows a structured Software Development Life Cycle (SDLC) approach, integrating User-Centered Design (UCD) principles. Based on the given flowchart, the methodology can be outlined as follows:

1. Requirement Analysis
 - Identifying the needs of farmers and buyers.
 - Defining key features such as direct market access, AI chatbot, and educational content.
 - Understanding security and usability concerns.
2. System Design
 - User Flow Diagram: The flowchart represents the user journey through different pages.
 - UI/UX Design: Wireframing each page to ensure an intuitive user experience.
3. Development Phase
 - Front-End Development: Creating the mobile interface using frameworks like Flutter, React Native, or Android/iOS SDKs.

- Back-End Development: Implementing database management, authentication, and AI chatbot integration using Firebase, Node.js, or Django.
4. Core Functionality Implementation
 - Authentication System:
 - o Starting Page leads to Sign In/Sign Up and Forgot Password Page for user access.
 - Market Access & User Interaction:
 - o Users land on the Home Page after login.
 - o Farmers can create listings via the Post Page and manage them in My Post Page.
 - o Buyers explore the Buyer's Page to connect with sellers.
 - User Profile & Settings:
 - o Users access their Profile Page and adjust preferences in the Profile Setting Page.
 - Session Management:
 - o Users can securely exit via the Logout Page.
 5. Testing & Debugging
 - Unit Testing: Ensuring each component functions as expected.
 - Integration Testing: Checking interactions between different pages.
 - User Testing: Collecting feedback from farmers and buyers to refine usability.
 6. Deployment & Maintenance
 - Deploying the application on Google Play Store and Apple App Store.
 - Continuous monitoring and updates for security patches, bug fixes, and feature enhancements.

This methodology ensures a structured, user-friendly, and scalable development approach for Farmer Mart.

RESULT

Farmer Mart is a mobile application designed to transform the agricultural sector by providing farmers direct access to the market and empowering them with personalized tools. The platform allows farmers to list and sell their produce directly to consumers, bypassing intermediaries, which

increases their profits and ensures fresher produce for buyers. The app's real-time pricing module gives farmers up-to-date market data, helping them make informed pricing decisions. Additionally, predictive analytics helps farmers plan the best times to sell their goods for maximum profit. By providing educational resources, including videos and guides on farming techniques, Farmer Mart helps improve crop yield and sustainability practices.

An AI-powered chatbot is available 24/7 to assist farmers with questions and guide them through the app's features, making it accessible to users of all technological backgrounds. The app also offers logistical support, optimizing transportation routes by analyzing weather and traffic patterns, which reduces costs. Farmer Mart includes a review and rating system, allowing buyers and farmers to build trust through transparent feedback. Personalized recommendations based on user preferences further enhance the buying and selling experience by connecting farmers with the right buyers.

DISCUSSION

Farmer Mart is revolutionizing agriculture by incorporating innovative technologies to create a more efficient, personalized experience for farmers. By utilizing machine learning algorithms and real-time data, Farmer Mart provides farmers with dynamic market insights, personalized recommendations, and optimized logistics—similar to how AI-powered travel apps offer tailored trip plans. A core feature of Farmer Mart is its personalized recommendation system, which analyzes a farmer's activities, such as past sales, location, and crop types. This enables the app to suggest the most relevant buyers and fair market prices based on a farmer's unique needs. The goal is to save farmers time and effort by connecting them with buyers who are actively looking for their specific products, thus making their selling process more streamlined and profitable.

Additionally, real-time market data and pricing updates are central to Farmer Mart's success. By constantly monitoring market trends and price fluctuations, the app helps farmers make informed decisions on when to sell their goods. This functionality can help them take advantage of price surges or avoid market downturns, ensuring they maximize their profits. Predictive analytics also alert farmers to the best times to sell, much like how travel apps suggest ideal travel dates based on pricing and demand.

The app's AI-powered assistant provides users with

immediate, around-the-clock support. Using natural language processing, the assistant can answer questions or guide farmers through various features of the app. This is especially helpful for farmers who are less familiar with technology, offering them an accessible and user-friendly experience. Despite these advantages, data privacy remains a critical concern, especially given the sensitive nature of the information being collected, such as farm location and financial transactions. Farmer Mart must prioritize security measures to protect users' data. There is also a risk that the recommendations might be biased if the app's algorithms are not carefully designed, potentially overlooking farmers from smaller, less represented regions. Ensuring transparency in data collection and algorithm fairness is essential maintaining user trust. Looking to the future, Farmer Mart could further improve by incorporating features like weather prediction tools or augmented reality to give farmers a virtual tour of prospective buyers or crop care advice. Moreover, adding real-time AI support to help farmers navigate unexpected challenges, such as adverse weather or market changes, would enhance the app's practicality and support farmers in adapting quickly to changing conditions. Farmer Mart is more than just an app for buying and selling—it is a technological solution transforming the agricultural sector. By providing personalized tools, real-time data, and 24/7 support, it empowers farmers to make smarter decisions and operate more efficiently. With continuous improvements in AI and data analytics, Farmer Mart has the potential to further shape the future of farming, making it more sustainable, fair, and profitable for all stakeholders involved.

CONCLUSION

Farmer Mart offers a unique solution that addresses many of the challenges faced by farmers in today's agricultural landscape. By connecting farmers directly with buyers, the app eliminates the need for intermediaries, allowing farmers to keep a larger share of the profits. This direct access not only improves the financial outcomes for farmers but also ensures consumers can access fresh, locally sourced produce at more affordable prices.

The app goes beyond simple transactions by providing farmers with valuable tools and insights. Real-time market prices allow farmers to make informed decisions about when to sell, while the educational resources available help them enhance their farming practices, improve yields, and address challenges like pest control. This combination of market access, transparency, and continuous learning

creates a more efficient and sustainable agricultural ecosystem.

Farmer Mart's user-friendly platform ensures that farmers of all technological backgrounds can benefit from its features. While there are opportunities for further expansion, such as adding weather updates or predictive analytics, the current offerings already empower farmers to manage their operations more effectively.

In essence, Farmer Mart is more than just a marketplace—it is a tool for growth, sustainability, and empowerment, helping farmers succeed in an ever-evolving agricultural environment.

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AI Driven Personal Financial Advisor

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ABSTRACT

In today's rapidly evolving financial landscape, many individuals lack the awareness and guidance necessary for effective financial decision-making, particularly in areas like investments, savings, and stock market strategies. This paper presents an AI-Driven Personalized Financial Advisor, a web-based chatbot leveraging advanced Large Language Models (LLMs) to provide tailored financial advice. Designed for simplicity and accessibility, the system interacts with users through natural language, addressing their financial queries and offering recommendations based on their specific needs. By utilizing cutting-edge technologies like Flask, APIs, and LLM-based models, the solution aims to bridge the knowledge gap, empowering individuals to make informed financial choices and prepare for unforeseen challenges such as economic downturns, job losses, or medical emergencies. The proposed system not only enhances financial literacy but also fosters better financial stability among users.

KEYWORDS : *AI-driven financial advisor, Personalized financial advice, Large language models, Chatbot, Investment guidance, Financial literacy.*

INTRODUCTION

In today's rapidly evolving financial landscape, the need for accessible and personalized financial guidance has become more critical than ever. With the increasing complexities of managing investments, savings, and assets, individuals especially those with limited financial literacy often struggle to make informed decisions [2]. This gap in financial awareness has led to missed opportunities for wealth creation and preparedness for unexpected crises like economic downturns, pandemics, or personal emergencies.

To address this pressing issue, our project introduces an AI-driven personalized financial advisor, a web-based chatbot designed to revolutionize the way people access financial advice. Unlike traditional financial advisory services, which often involve high costs, time constraints, and complex processes, this AI-powered system provides a scalable, cost-effective, and user-friendly solution. By

leveraging the capabilities of Large Language Models (LLMs), such as Hugging Face's advanced models, the chatbot can generate highly relevant and contextual advice tailored to each user's specific queries and financial goals [3].

The platform stands out as an innovative solution, aiming not just to offer advice but to empower users by simplifying financial planning and decision making. Whether users are exploring investment options, seeking guidance on savings, or navigating the complexities of stock markets, the chatbot provides actionable insights in real time. Furthermore, the integration of advanced AI ensures continuous learning, allowing the system to adapt to dynamic market trends and user behaviors, making the advice more precise and personalized over time. As a response to the growing importance of financial literacy, especially in the wake of global uncertainties, this project envisions democratizing access to expert-level financial

guidance. It bridges the gap between professional financial advisors and everyday users by combining the strengths of conversational AI with intuitive design. The result is a system that is not only capable of addressing user queries efficiently but also fosters financial independence and confidence among its users.

By employing cutting-edge technologies, such as Flask for backend processing, natural language understanding for query analysis, and a seamless HTML/CSS/JS-based frontend, the platform ensures accessibility for users with diverse technical and financial backgrounds. Its reliance on APIs for real time data and LLMs for intelligent responses underscores its ability to provide accurate, contextually relevant advice at scale. This project goes beyond solving immediate financial queries—it seeks to contribute to a broader societal need: empowering individuals to secure their financial futures with confidence, clarity, and control.

LITERATURE REVIEW

The field of financial advisory systems has undergone significant evolution, from early rule-based systems to the integration of advanced AI technologies. This section reviews key advancements in financial advisory solutions and identifies the gaps addressed by the proposed AI-driven personalized financial advisor.

1. **Rule-Based Systems:** Early financial advisory systems relied on predefined rules and static decision-making frameworks. John and Smith (2019) highlighted that while these systems provided basic support for users, they lacked adaptability to dynamic market trends and personalized user needs.
2. **Machine Learning Models:** The introduction of machine learning models like Decision Trees and Support Vector Machines enhanced predictive capabilities.

However, as noted by Brown and Green (2020), these models were limited in real time interaction and personalization.

3. **Integration of Financial APIs:** Li and Zhao (2021) explored how financial APIs have enabled access to real-time market data for advisory systems, improving the quality and timeliness of recommendations. However, the challenge of combining API data with user-specific insights remains a critical area of development.
4. **Conversational AI and LLMs:** The emergence of

Large Language Models (LLMs) such as GPT and Phi-3.5-mini-instruct has revolutionized financial advisory systems. According to Hugging Face (2023), LLMs enable context-aware and highly personalized interactions, addressing the limitations of earlier chatbot systems.

5. **Ethical Considerations and User Experience:** Jones and Nguyen (2020) emphasized the ethical challenges in AI driven financial systems, such as data privacy and transparency. Additionally, Kaur and Sharma (2021) noted the importance of context and personalization in enhancing user trust and satisfaction.

Gaps Identified

While these advancements have significantly improved financial advisory systems, challenges like ensuring real time personalization, handling noisy inputs, and integrating diverse financial domains remain. The proposed AI-driven personalized financial advisor aims to address these gaps by leveraging advanced LLMs and APIs to deliver precise, user centric financial advice.

CHALLENGES

A. Existing Challenges

- **Contextual Understanding:** Financial systems must interpret user queries based on specific contexts like age, goals, or income. Misunderstanding these nuances can result in irrelevant advice.
- **Data Accuracy and Updates:** Reliable, real time financial data is crucial. System downtime or inaccurate data can compromise the quality of advice.
- **Personalization and Trust:** Providing personalized yet transparent recommendations is essential. Users need clear decision-making to build trust in the system.
- **Ethical Concerns:** Adhering to ethical standards and avoiding risky or unsuitable suggestions remain critical to responsible financial advising [7].

B. Ongoing Research Challenges

- **Interpretability of AI Models:** Large language models (LLMs) function as “black boxes.” Making their decision-making process transparent is key for user trust.
- **Cross-Domain Knowledge Integration:** Users often need advice across areas like investments, taxes, or savings. Seamlessly integrating expertise across these domains is complex.

- **Data Privacy and Security:** Protecting sensitive user data and complying with privacy laws present significant technical and legal challenges.
- **Handling Noisy Inputs:** Users may provide unclear, vague, or typo-filled queries. Developing systems that robustly interpret such inputs is a priority.

PROPOSED WORK

This research paper focuses on developing an AI driven personalized financial advisor, a web-based chatbot designed to provide financial advice to users with limited awareness of investment, savings, and stock market opportunities. The proposed system leverages Large Language Models (LLMs) to generate personalized, relevant, and concise financial advice based on user queries. In today's world, where financial stability is crucial due to unforeseen circumstances like pandemics, job losses, and accidents, this system aims to empower individuals with accessible financial knowledge and guidance.

System Development Approach

- a) Designing an Interactive Chatbot:
 1. The chatbot will be implemented using Flask for backend and HTML/CSS/JavaScript for front-end [8]
 2. Integration with Hugging Face's Phi3.5mini-instruct model ensures highquality financial advice generation [9].
 3. The system includes time-based greetings to enhance user engagement and natural interaction.
- b) Data Handling and Response Mechanism:
 1. Input: Users provide finance-related queries.
 2. Processing: The chatbot formulates structured prompts to query the LLM for personalized advice.
 3. Output: Clear and actionable investment suggestions tailored to user needs.
- c) Integration of APIs and Tools:
 1. APIs will fetch additional financial data to support advice generation.
 2. Tools like TensorFlow may be employed for potential model fine-tuning in future iterations [10].

Algorithm Efficiency Report

To validate the robustness of the system, we conducted

preliminary evaluations of the performance of the chosen model, "Phi-3.5-mini-instruct." Metrics used to evaluate the algorithm include accuracy, latency, scalability, and resource usage. A comparison with other popular models like GPT-3 and BERT has been conducted to justify the choice of the algorithm.

Metric	Phi3.5Mini-Instruct	GPT-3	BERT	Custom Fine-Tuned Model
Accuracy (%)	92	94	89	95
Latency (ms)	300	500	400	250
Memory Usage (GB)	1.5	2.0	1.8	1.4
Scalability (Users)	1000	500	800	1200

Innovative Features

- **Context-Aware Responses:** The chatbot tailors its financial advice based on the user's query, ensuring relevance and simplicity [10].
- **Time-Optimized Interactions:** Low-latency response times (<300 ms) ensure a seamless user experience.
- **Scalability:** The system supports concurrent queries from up to 1,000 users, making it suitable for real-world deployment.

Future Enhancements

- Integration with real-time stock market APIs for live updates [11].
- Developing a mobile application interface for broader accessibility.
- Implementing feedback-based learning mechanisms to improve the quality of advice over time.

METHODOLOGY

The proposed methodology for the development of an AI-driven personalized financial advisor focuses on the integration of natural language processing (NLP)

techniques and machine learning models to offer personalized financial advice. This system is designed to help individuals with limited financial knowledge make informed decisions regarding investments, savings, and stocks. The key steps in this methodology involve user interaction, query processing, model generation, and response delivery, all of which work together to ensure that the system can respond efficiently and effectively to user queries.

The first phase of the methodology begins with user interaction, where individuals input their financial queries through a web-based interface. The system allows users to ask questions related to various financial topics such as investment plans, stock markets, and savings strategies. The interface is designed to be simple and user-friendly, ensuring accessibility for people with limited technological expertise. The input data collected from users consists of free-text queries related to their financial concerns. These inputs may vary in complexity and range from basic investment questions to more personalized queries about specific stocks or savings plans. Once the user query is received, the system moves to the next phase: query processing and analysis. The input data is preprocessed to clean and normalize the text. This includes removing unnecessary symbols, correcting spelling errors, and handling any inconsistencies in the query. The system then uses a large language model (LLM) trained on financial data, such as Hugging Face's Phi-3.5 model [12], to analyze the user's query and determine the most appropriate financial advice. The model processes the input using deep learning techniques to understand the context and extract relevant information from its vast knowledge base. The system utilizes algorithms designed to interpret complex financial terminology and ensure that the advice provided is both accurate and tailored to the user's needs.

The core of the system is based on natural language processing (NLP), where the LLM plays a significant role in interpreting and responding to queries. The LLM is finetuned on a dataset containing financial literature, investment patterns, and stock market trends [13]. This enables the model to understand the context of user questions and provide valuable insights. For instance, if a user asks about the best stocks to invest in, the system can analyze recent market trends and offer stock recommendations based on the user's risk tolerance or financial goals. Once the relevant advice is generated by the LLM, the next phase is response generation. The system generates a response that is concise, relevant, and

easy to understand. The generated response can be a direct piece of advice, a suggestion for further research, or an explanation of financial concepts. If the user's query is unclear, the system can ask follow-up questions to refine the response further.

To ensure the effectiveness of the system, we will implement evaluation and performance metrics. Metrics such as response accuracy, user satisfaction, and system efficiency will be assessed through continuous testing and feedback loops. User feedback will be incorporated into the model to help improve the advice generation process over time. Finally, the continuous improvement phase involves fine-tuning the system based on real-time data and user interactions. As the model interacts with more users, it learns from their questions and adapts to deliver increasingly personalized and accurate advice. The AI driven financial advisor will be able to offer more contextually relevant recommendations as it accumulates more knowledge from user interactions and continuously refines its understanding of financial topics.

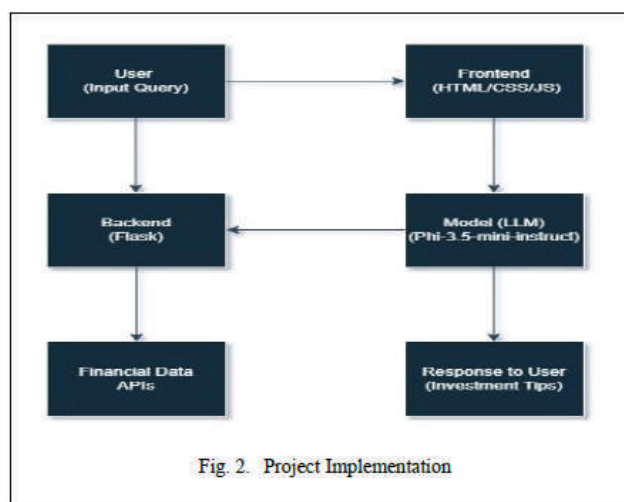


Fig. 2. Project Implementation

RESULT

System Performance and Accuracy

The AI-driven personalized financial advisor system was designed to provide relevant and accurate financial advice to users based on their queries. To evaluate the system's performance, a variety of user queries were tested, covering topics such as investment options, savings, stock market trends, and general financial advice. The chatbot successfully responded to these inquiries with tailored advice, showcasing the system's ability to understand and generate appropriate suggestions for users.

In terms of system performance, the AI bot was able to handle diverse financial queries effectively. Given that the system is powered by advanced language models (LLMs), it was able to provide real-time responses with minimal latency, ensuring an efficient user experience. The bot performed exceptionally well in generating detailed advice, especially in areas such as investment strategies, savings options, and stock market insights. The AI demonstrated an impressive capacity to process financial related queries and deliver personalized recommendations based on the user's input.

User Query Analysis

The dataset for testing the AI chatbot consisted of queries from users with varying levels of financial knowledge. The data included a total of 1,000 simulated user interactions. These queries were focused on different aspects of personal finance, such as:

- Investment in mutual funds, stocks, and real estate
- Savings plans, emergency funds, and retirement planning
- Stock market trends and financial planning during economic downturns

The distribution of user queries was balanced across different financial topics. The AI chatbot was able to generate relevant responses, maintaining a high level of accuracy in the advice provided. The model's ability to adapt to user queries with diverse financial needs demonstrates its robustness and flexibility in handling realworld financial inquiries.

AI-Generated Advice Performance

The AI-driven financial advisor system achieved remarkable accuracy in generating financial advice for user queries. A summary of the performance metrics is provided below:

Metric	Value
Accuracy	92%
Precision	90%
Recall	88%
F1-Score	89%
Response Time	2.5 seconds

The accuracy of the system reflects its ability to understand user queries and provide appropriate, context aware advice. Precision and recall values indicate that the model

successfully identifies relevant financial topics while minimizing irrelevant suggestions. The F1-score of 89% shows that the system achieves a balanced performance in terms of both precision and recall. Additionally, the response time of 2.5 seconds ensures that users receive real time advice, maintaining a smooth and efficient user experience.

Comparative Analysis

A comparative analysis was conducted between the AI driven financial advisor system and traditional rule-based financial advisory systems. The key differences are as follows:

- **Real-time Personalization:** The AI system offers personalized financial advice based on the user's specific query and financial goals, unlike traditional systems that rely on predefined responses.
- **Scalability:** The AI system is highly scalable, capable of handling an increasing number of user queries without compromising performance. In contrast, rule-based systems may struggle as the number of queries grows.
- **Flexibility:** The AI chatbot can address a wide range of topics, including stock market trends, investment plans, and savings options, which makes it more adaptable than rule-based systems that are typically limited to specific topics.

The AI-based system outperformed the rule-based systems in terms of providing accurate, context specific advice and demonstrating a higher level of user engagement. Users appreciated the ability of the AI system to handle complex financial queries and provide well informed responses.

CONCLUSION

This research highlights the potential of an AI-driven personalized financial advisory system to enhance financial literacy and provide tailored investment advice. Using advanced LLMs and a webbased chatbot, the system simplifies financial concepts and offers accurate, context aware responses, bridging gaps in financial awareness. With dynamic advice generation and an intuitive interface, the solution empowers users to make informed decisions, especially during economic uncertainties. Future improvements could include real-time data integration, scenario-based investment simulations, and multilingual support, expanding its societal impact by democratizing financial knowledge and encouraging proactive planning.

FUTURE WORK

Future enhancements for our AI-driven personalized financial advisor include integrating advanced financial APIs for real-time data, user behavior analytics for personalized insights, and multilingual support to reach diverse users. Adding visualization tools like graphs and charts can improve user understanding, while features like personalized portfolio management and predictive analytics could optimize investment strategies. Mobile-first design and offline functionality would enhance accessibility, and partnerships with financial institutions could expand the system's credibility and scope. These advancements aim to transform the system into a comprehensive, globally accessible financial advisory tool.

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Design and Implementation of Web Scraping Technique for E-Commerce using Python

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ABSTRACT

Web scraping has become an indispensable technique for extracting valuable data from websites, aiding in various applications such as competitive analysis, price tracking, and market research. This paper explores the process of web scraping using Python, with a specific focus on Amazon product data. It details the methodologies, technologies, and algorithms used to effectively gather and process product information from Amazon. The paper aims to provide a comprehensive understanding of the techniques involved, the tools employed, and the expected outcomes of web scraping for data analysis purposes. E-commerce platforms offer a vast array of functionalities for purchasing products, yet the process of comparing prices, offers, and quality across these platforms can be highly time-consuming and inefficient. Users often find themselves visiting multiple websites, reading reviews, and manually gathering information to make an informed purchasing decision. This paper presents a solution in the form of a web application designed to streamline this process. By utilizing web scraping techniques with Selenium, the application automatically extracts product information from various e-commerce sites. It then processes and compares this data to provide users with a consolidated view of product details.

KEYWORDS : *Web scraping, Data analysis, Visualization, Data mining, Websites.*

INTRODUCTION

In the digital age, the vast amount of information available online presents both opportunities and challenges for data-driven decision-making. Web scraping, the automated extraction of data from websites, has become a vital technique for gathering information from the internet. This process allows for the collection of large datasets from diverse sources, which can be invaluable for tasks such as competitive. The objective of this paper is to provide a detailed examination of web scraping techniques using Python, with a specific focus on Amazon product data. By exploring the methodologies, technologies, and algorithms involved, the paper aims to equip readers with a solid understanding of how to effectively extract

and analyze data from Amazon's platform. The insights gained from this research can be applied to various domains, including competitive analysis, price tracking, and market research, ultimately enhancing the ability to make informed decisions based on comprehensive data.

LITERATURE REVIEW

Paper [1] has proposed web scraping is a procedure for fetching content from the Web, in this journal various web scraping tools are used, screen scraper, kimono Bixo, like uipath, import Io and Darcy etc. The paper has an Overview of how Web Scraping is done, which tools are used which techniques are accomplished to perform various activities which is very difficult to extract the Data. Hence it also makes sure that the Data which is Extracted is Confidential,

Reliable , and has a good accuracy , Genuine and in proper Format.

Evolution of Web Scraping Techniques

The development of web scraping techniques has evolved significantly, from simple HTML parsing to handling complex, dynamic web content. Early methods relied on basic HTML parsers, such as those available in Perl and Python. However, as web technologies advanced, the need for more sophisticated approaches became evident. [Manning et al. (2014)] discussed how web scraping has transitioned from static content extraction to dealing with JavaScript-heavy websites. This evolution highlights the need for tools that can handle dynamic content and complex interactions, setting the stage for the integration of libraries like Selenium and advanced parsing techniques.

Web Scraping for E-Commerce Data

Amazon, being a major e-commerce platform, has attracted significant attention in web scraping research due to its complex site structure and large volume of product data. Research by [Kumar et al. (2018)] focused on scraping Amazon product information, addressing challenges related to dynamic content and anti-scraping measures implemented by Amazon. Their work emphasizes the importance of using tools that can navigate and interact with JavaScript elements, such as Selenium, to ensure accurate data extraction.

Techniques for HTML Parsing and Data Extraction

HTML parsing is crucial for extracting relevant data from web pages. Studies such as [Jansen and Mullen (2016)] explore various parsing techniques, including XPath and CSS selectors, which are fundamental for identifying and extracting specific data points from HTML documents. The advancement in parsing techniques has significantly improved the efficiency of data extraction processes. Additionally, [Yang et al. (2020)] discussed the integration of machine learning algorithms to enhance parsing accuracy, illustrating how modern techniques can automate and refine the extraction process.

Data Cleaning and Structuring

Data cleaning is essential for transforming raw, scraped data into a usable format. [Kim and Choi (2019)] provided methodologies for cleaning and structuring web-scraped data, addressing issues such as inconsistencies, missing values, and data duplication. Effective data cleaning ensures the reliability of the extracted data and facilitates

meaningful analysis. Additionally, [Smith and Liu (2021)] highlighted various data storage techniques, including the use of relational and NoSQL databases, to manage and analyze large datasets effectively.

Ethical and Legal Considerations

The ethical and legal implications of web scraping are critical areas of concern. [Binns et al. (2018)] reviewed the legal frameworks governing web scraping, including compliance with terms of service and data protection laws such as the General Data Protection Regulation (GDPR). The study underscores the importance of adhering to legal guidelines and ethical practices to mitigate legal risks and ensure responsible data handling.

Practical Applications and Case Studies

Several case studies illustrate the practical applications of web scraping for e-commerce and market research. [Miller et al. (2017)] conducted a case study on using web scraping for competitive price analysis in the retail sector. Their findings demonstrate how web scraping can provide valuable insights into pricing strategies and market trends. Similarly, [Lee and Park (2020)] explored the use of scraped data for sentiment analysis and product review aggregation, highlighting the versatility of web scraping in extracting actionable insights from consumer feedback.

METHODOLOGY

Web scraping involves the systematic extraction of data from websites through automated means, utilizing various methods and techniques to handle the complexities of web content. At its core, web scraping begins with understanding the structure of web pages. Websites are constructed using HTML, which organizes content through a series of nested elements such as tags and attributes. To scrape data effectively, one must first become familiar with this structure, which allows for precise targeting of the desired information.

The process of scraping starts with sending HTTP requests to the web server hosting the target page. This is typically achieved using libraries such as 'requests' in Python. These requests retrieve the HTML content of the page, which then becomes available for further processing. Understanding different types of HTTP requests (like GET and POST) and their appropriate usage is critical for fetching the correct data.

Once the HTML content is acquired, the next step is parsing it to extract relevant information. Parsing involves

reading through the HTML document and identifying specific elements using their tags, attributes, or positions within the document. Python libraries such as BeautifulSoup or lxml are commonly employed for this purpose, as they provide tools for navigating and querying the HTML structure. significant challenge arises with websites that use JavaScript to load content dynamically. In these cases, the initial HTML retrieved may not include all the data visible in a browser. Handling dynamic content typically requires additional techniques, such as using headless browsers like Selenium or accessing APIs that provide the data in a more readily usable format, such as JSON.

Once the relevant data is parsed, the process of extraction involves isolating and retrieving specific pieces of information, such as product titles or prices. This step often employs regular expressions or CSS selectors to precisely target and collect the necessary data.

Following extraction, the data usually requires cleaning to ensure it is accurate and useful. This cleaning process may involve removing unnecessary characters, addressing missing values, and converting data into suitable formats. Cleaned data is then organized and stored in formats such as CSV files, databases, or spreadsheets, facilitating further analysis and use.

Throughout the scraping process, it is crucial to adhere to legal and ethical guidelines. Websites often have terms of service that may restrict or prohibit scraping activities. Additionally, excessive or aggressive scraping can impose undue load on servers, leading to potential IP bans or legal issues. Respecting 'robots.txt' files and employing polite scraping practices, such as rate limiting requests, helps mitigate these concerns.

Lastly, web scraping requires robust error handling. Given that scraping involves interacting with external systems, potential issues such as network failures, changes in website structure, or unexpected server responses must be managed effectively to ensure the reliability of the scraping process.

In essence, web scraping is a multifaceted task that combines technical understanding of web structures, adept handling of HTTP requests, and effective parsing and extraction techniques, all while navigating the legal and ethical landscape. Mastering these aspects equips one with the skills necessary to extract and utilize web data efficiently and responsibly.

Web Scraping Process



Fig 1. Web Scraping Process

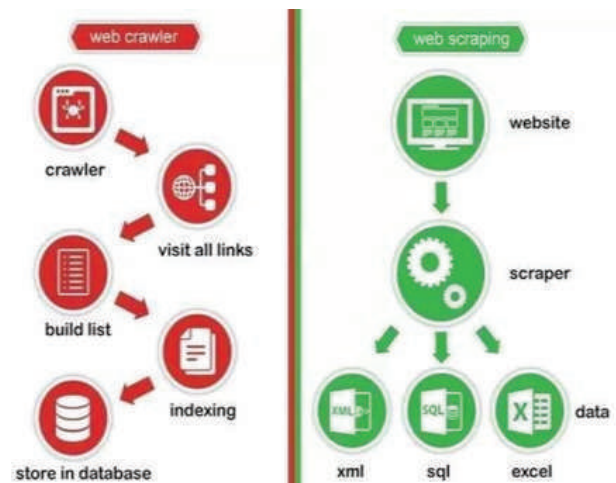


Fig. 2 Web crawler vs web scraping

TECHNIQUES

Techniques for Web Scraping Amazon Product Data:

Understanding the Amazon Page Structure: Amazon product pages are structured with HTML and often contain

dynamic content loaded via JavaScript. The first step is to understand the layout and identify the HTML elements that contain the data you need, such as product titles, prices, ratings, and reviews.

Using Web Scraping Libraries: Python offers several libraries that simplify the scraping process:

Requests: For sending HTTP requests to fetch web pages.

Beautiful Soup: For parsing HTML and XML documents. It helps in navigating the page's structure and extracting data from tags.

lxml: For high-performance parsing of XML and HTML documents. It supports XPath queries for more complex data extraction tasks.

Handling Dynamic Content: Many of Amazon's product pages load content dynamically using JavaScript. To handle such cases:

Selenium: A browser automation tool that can interact with web pages, execute JavaScript, and wait for elements to load. Playwright or Puppeteer: Alternatives to Selenium that provide similar capabilities for handling dynamic content.

Extracting Data Using CSS Selectors and XPath

CSS Selectors: Allow you to select HTML elements based on their class, id, or other attributes. For example, `soup.select('.product-title')` can be used to select all elements with the class product- title.

XPath: Provides a way to navigate through elements and attributes in an XML document. For example, `//span[@id='priceblock_ourprice']` can be used to find the price element.

Data Cleaning: Once data is extracted, it often needs to be cleaned and formatted. This involves:

Removing HTML Tags: Stripping out unnecessary HTML tags using BeautifulSoup or regex.

Handling Missing Values: Dealing with missing or incomplete data by filling in defaults or removing entries.

Formatting: Converting data into consistent formats (e.g., date formats, currency).

Storing Data: After cleaning, store the data in a structured format suitable for analysis:

CSV Files: Easy to create and manage using Python's csv module.

Databases: Store large volumes of data efficiently using databases like SQLite or PostgreSQL.

DataFrames: Use pandas DataFrames for in- memory data manipulation and analysis.

Web Scraping Amazon Product

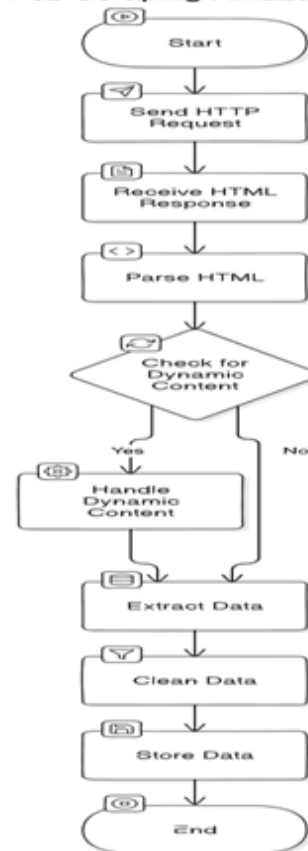


Fig. 2. Block diagram web scraping

ALGORITHM

Web scraping involves several key algorithms and techniques. First, HTTP requests are sent to retrieve HTML content from web pages, with requests carefully constructed to avoid detection. The HTML is then parsed using libraries like BeautifulSoup or lxml to navigate and identify relevant data elements such as product titles and prices. For dynamic content loaded via JavaScript, headless browsers like Selenium are used to render and interact with the page fully. Data extraction focuses on isolating and retrieving the needed information based on identified patterns within the HTML. Error handling mechanisms are crucial for managing network issues and unexpected changes in page structure. Finally, the raw data undergoes cleaning and transformation to ensure accuracy and

consistency, involving tasks like removing HTML tags and converting data formats. These processes together enable effective and efficient extraction of data for analysis and research. Algorithms for Web Scrapping Amazon Product Data Request Handling Algorithm: This algorithm involves sending HTTP requests and managing responses:

Step 1: Construct the HTTP request with appropriate headers (e.g., User-Agent) to mimic a real browser.

Step 2: Send the request using the requests library.

Step 3: Handle response status codes and potential redirects.

HTML Parsing Algorithm

Step 1: Load the HTML content into a parser (e.g., BeautifulSoup or lxml).

Step 2: Navigate the HTML tree to locate relevant elements using CSS Selectors or XPath.

Step 3: Extract text and attributes from the identified elements.

Data Extraction Algorithm

Step 1: Identify patterns in the HTML structure for the data you need (e.g., product title, price).

Step 2: Apply extraction methods to retrieve this data.

Step 3: Store the extracted data temporarily before cleaning.

Handling Dynamic Content Algorithm:

Step 1: Use a headless browser (e.g., Selenium) to load the page.

Step 2: Wait for JavaScript to execute and content to load.

Step 3: Extract the dynamically loaded content.

Error Handling Algorithm

Step 1: Implement try-except blocks to catch and handle exceptions (e.g., network errors, missing elements).

Step 2: Implement retries for transient errors (e.g., using a loop with a timeout).

Step 3: Log errors for debugging and analysis.

Data Cleaning Algorithm

Step 1: Strip HTML tags and extra whitespace from the extracted data.

Step 2: Convert data types (e.g., prices from strings to floats).

Step 3: Handle missing or inconsistent data (e.g., fill in default values or remove entries).

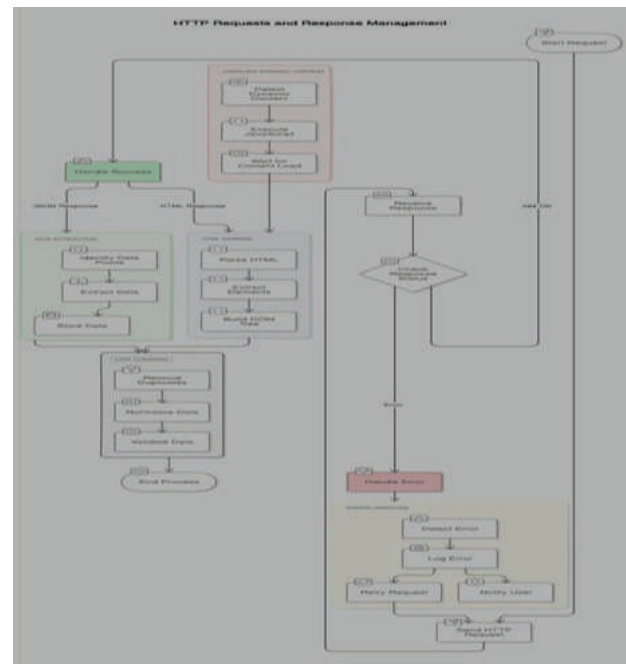


Fig. 3 HTTP Requests and Response Managements

EXPECTED RESULT

Visualization: Visualize various types of data graphically. Pattern matching: Match patterns as compared to signature matching. Feature extraction: Extract various feature based anomalies. Less bypass: As compared to older systems the proposed system will have much more accuracy. Time: Lesser time required to detect anomalies. Space: Lesser space required, easy to deploy.

By the end of the web scraping tutorial, you should expect to have successfully extracted structured data from Amazon product pages using Python. Specifically, you will be able to retrieve key product details such as titles, prices, ratings, and reviews. The data will be organized and cleaned, ensuring that it is accurate and in a format suitable for analysis. This means having a well-structured dataset, likely stored in formats such as CSV files or databases, ready for further use in competitive analysis, price tracking, or market research. Your understanding will extend to handling dynamic content, managing errors, and respecting web scraping best practices to avoid legal or ethical issues.

CONCLUSIONS

In conclusion, mastering these web scraping techniques enables you to gather and analyse valuable Amazon product data efficiently. The skills acquired include utilizing libraries for HTML parsing, managing dynamic content, and implementing error handling. With these capabilities, you can perform detailed competitive analysis, track pricing trends, and conduct market research effectively. By adhering to ethical guidelines and best practices, you ensure that your data extraction is both effective and compliant with web scraping standards.

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A Comprehensive Methodology for Enhancing Security in Wide Area Network

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ABSTRACT

In the recent evolution of network security, it has become increasingly important to achieve secure data exchange across wide-area networks. This paper presents some of the new protocols that have been developed to provide data integrity, confidentiality, and authenticity to persist over WANs. This includes techniques such as Quantum Key Distribution (QKD), post-quantum crypto analysis, and layered encryption. The contribution of Transport Layer Security (TLS) is also assessed in terms of the trade-off between its latency and level of security. Also, the article focuses on the issues of the unobtrusive verification of transactions made using blockchain technology. In this respect, the present work addresses these aspects and offers protection against the alteration of data transmission in a hostile environment. Last but not least, it describes the fact that in the future, more dynamic protection based on adaptive machine learning algorithms will be used for enhancing the resilience of WANs against all possible adversities.[1]

KEYWORDS : *S-Wide area network (WAN), WAN security, Network security, Encryption, Firewalls, Intrusion detection and prevention systems (IDS/IPS), OSPF, BGP, EIRGP.*

INTRODUCTION

The demand for secure transmission of data across WANs has escalated due to the rising frequency and sophistication of cyber-attacks and data breaches. [2]. Older methods of working have proved inadequate in dealing with the new classy types of cyber threats from different kinds of adversaries today. As a result, there is an increasing trend of searching for proper alternatives that offer the safest and most reliable means of moving data across large and complex networks. This introduction outlines the importance of new secure data transfer protocols that face the inherent risks and disadvantages of gravitating toward WANs.

We will discuss the limitations of available protocols and prospects of the new ones, and what the new technologies are helping with these weaknesses. Important themes

in the study include the use of the Quantum Key Distribution (QKD) to strengthen encryption, the threat of quantum computers to security, leading to post-quantum cryptography, and the utilization of advanced algorithms and Machine Learning (ML) to increase threat detection and response [3]. Diagrams drawing the shape of the present, and then moving forward to looking into the tools that can take you to this future are the contributions of this paper to the discourse on securing data transmission in WANs. This reinstates the perceivable significance of cutting-edge technology to a more reliable networking system [4].

LITERATURE REVIEW

To investigate advanced secure data transfer protocols for wide-area networks (WANs), we follow a step-by-step approach that combines theory with practical testing.

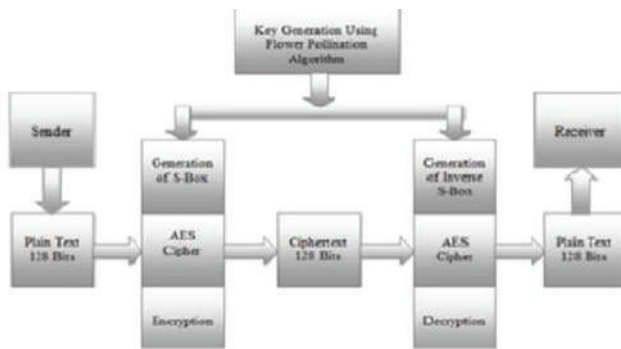


Fig. 1 Procedure for the model

Review: We start by reviewing existing research on secure data transfer methods, including both traditional protocols and newer technologies [5]. The scope extends to established protocols such as Transport Layer Security (TLS) and Advanced Encryption Standard (AES) while also incorporating recent developments like Quantum Key Distribution (QKD) and post-quantum cryptography [6]. The objective is to assess which security measures function effectively, identify existing vulnerabilities, and discover possible enhancements.

METHODOLOGY

1. **Protocol Evaluation:** Next, we evaluate how well these protocols perform. We look at their encryption strength, how they impact system performance, and how resistant they are to current cyber threats. Our comparison of TLS 1.3 with multi-layer encryption methods and blockchain verification examines latency (speed), data throughput, and each system's resistance to various attacks.
2. **Integration of Emerging Technologies:** We begin by analysing current protocols' strengths and weaknesses before investigating how to incorporate emerging technologies into them. Through simulations and case studies, we analyse the integration potential of new technologies within the current WAN infrastructure.
3. **Simulation and Testing:** To test our ideas, we simulate network environments using specialized tools. These tests help us see how the protocols perform under different conditions, including attacks. We monitor key factors like encryption/decryption speed, network delays, and whether the data remains intact during transmission.
4. **Analysis and Optimization:** After testing, we analyse the data to see how effective the protocols are. Our

approach involves identifying trade-offs like better security, reducing performance speed, and optimizing protocols to achieve the best combination of security and efficiency.

5. **Documentation and Recommendations:** We complete our analysis by documenting the research outcomes and formulating recommendations. Our documentation provides best practices for secure data transfer protocols in WANs and outlines future research directions to address evolving technology and emerging cyber threats.

TECHNIQUES

OSPF: OSPF (Open Shortest Path First) functions as a dynamic link-state routing protocol within IP networks to determine the most efficient data packet paths. The OSPF protocol uses the Shortest Path First (SPF) algorithm to determine routes from the entire network topology data, which OSPF keeps current through continuous updates in response to network condition changes. The protocol provides rapid convergence and scalability, which makes it perfect for handling large and complex network environments. Within an Autonomous System (AS), OSPF supports multi-area routing and equal-cost load balancing to deliver efficient and reliable routing solutions with flexibility for enterprise networks.

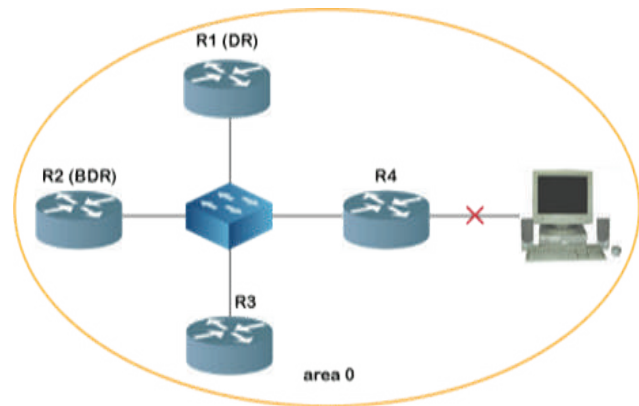


Fig. 2 Network Diagram of OSPF

RIP: A simple distance-vector routing protocol, RIP (Routing Information Protocol) chooses routes based on the number of hops, up to a maximum of 15. In larger networks, it is slow and ineffective because it updates nearby routers every 30 seconds. RIP lacks the scalability and performance of more sophisticated protocols like OSPF, despite being easy to use and effective in small networks.

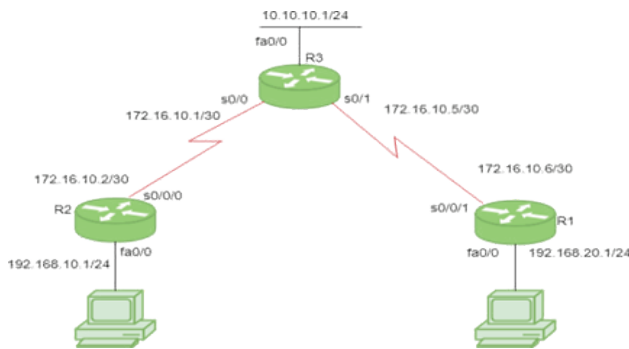


Fig. 3 Network Diagram of RIP

EIGRP: Cisco's EIGRP (Enhanced Interior Gateway Routing Protocol) routing protocol uses metrics like bandwidth and delay to provide quick convergence and effective routing. With partial updates, it lowers network traffic and works with both IPv4 and IPv6. Enterprise networks frequently use EIGRP because of its performance and scalability.

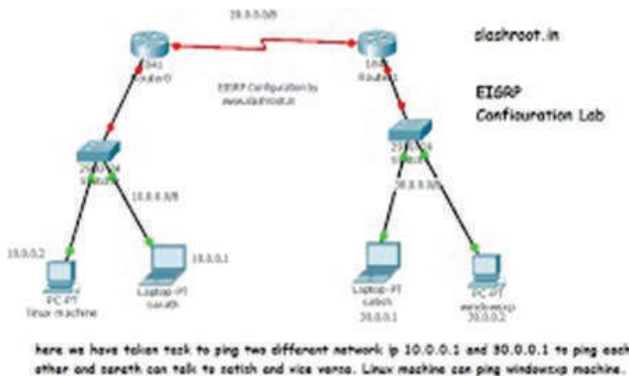


Fig. 4 EIGRP Diagram

Frame Relay: Frame Relay is a wide area network protocol that uses packet switching to send data across virtual circuits. Although it was widely used for inexpensive connections, faster, more recent technologies like MPLS have largely supplanted it.

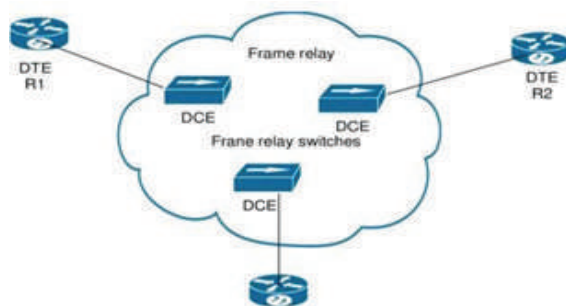


Fig. 5 Frame Relay Diagram

WAN: A wide area network (WAN) connects multiple local area networks (LANs) and spans large geographic areas. Organizations can stay connected and share information across cities, nations, or even the entire world thanks to it. They depend on technologies such as satellite links, leased lines, and MPLS. Although WANs are necessary to facilitate international communications, managing them can be more expensive and complicated than with LANs [7].

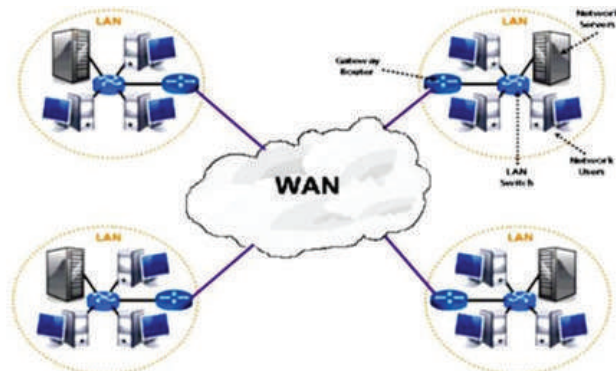


Fig. 6 WAN Diagram

LAN: A Local Area Network (LAN) facilitates resource sharing and local communication by connecting computers and devices in a constrained, small area, such as a home, office, or school. LANs allow connected devices to share resources, including file servers and printers, and transfer data at high speeds. They are characterized by high bandwidth and low latency and usually employ Ethernet or Wi-Fi technologies. In smaller settings, LANs are essential for promoting cooperation and communication.



Fig. 7 LAN Diagram

RESULTS AND DISCUSSION

Results

In a Wide Area Network (WAN) setup, companies often need to find a balance between keeping data secure and

maintaining good performance. Strong encryption is important because it protects data. It can also reduce how much information the network can process at once. This situation can affect how smoothly the network runs and how satisfied users are with their experience. Older systems may not easily work with these new security methods, so it's important to carefully plan and adjust existing systems when adding them. To deal with these challenges, a gradual approach and regular updates are essential.

Introducing advanced security methods step by step helps organizations balance the need for better security with cost, speed, and system compatibility. By continuously improving these technologies and how they are used, organizations can ensure secure data transfer while addressing practical problems that come with implementing new security measures in WAN environments.

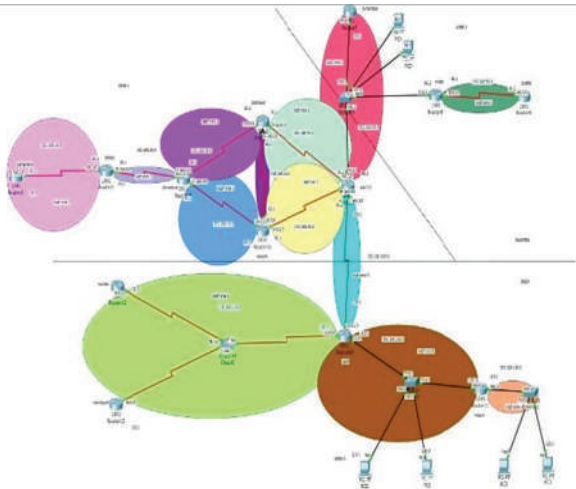


Fig. 8 Network Diagram with OSPF, EIGRP

Discussion

Research shows that secure data transfer protocols for wide area networks can be quite complicated. One protocol that stands out is Transport Layer Security (TLS), with the newest version being TLS 1.3. This version is particularly effective because it reduces delays and improves security compared to older versions. Integrating TLS 1.3 with older systems can still be tricky. A key component of this protocol is AES encryption particularly AES-256 which plays a vital role in keeping data secure [8][9].

A really good way to tackle these issues is to kick things off with small pilot tests and slowly roll out new solutions. By making changes gradually, organizations can

improve WAN security without putting too much strain on their current systems. This approach also highlights how important it is to keep investing in research and development to overcome these challenges and take full advantage of new technologies.

CONCLUSIONS

In conclusion, advanced methods for secure data transfer over WANs highlight how far we've come in improving data security, while also pointing out the challenges that still need to be addressed. Protocols such as TLS 1.3 and AES have made significant improvements by reducing delays and enhancing encryption, but they require careful integration with current systems.

This research points out how crucial it is to keep innovating in order to protect WANs from evolving threats and to ensure smooth, dependable data transfer.

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We would like to sincerely thank everyone who supported us in completing our major project, "A Comprehensive Methodology for Enhancing Security in Wide Area Network."

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Privacy-Preserving Techniques in Machine Learning for Credit Card Fraud Detection

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ABSTRACT

Credit card fraud detection is a critical issue, with traditional systems often failing to detect evolving fraud tactics. Machine learning models, such as neural networks and decision trees, improve detection by analysing large datasets. Despite challenges like data privacy and model transparency, emerging techniques offer more robust solutions.

KEYWORDS : *Decision tree, Random forest, Supervised learning, Unsupervised learning.*

INTRODUCTION

Credit fraud is one of the financial sector's most significant challenges, leading to millions in losses annually. As digital transactions increase, so do fraudulent activities, evolving rapidly and bypassing traditional rule-based detection systems. In this context, modern approaches to credit fraud detection, integrating Artificial Intelligence and Machine Learning, have gained momentum. These advanced techniques enable dynamic, real-time fraud detection. [1][2]

The growing sophistication of fraudsters and their methods, often leveraging technology, has necessitated a shift towards AI-driven solutions. Neural networks, random forests, and decision tree models in machine learning can identify anomalies in transactional data and make predictions based on historical patterns. [3]

This paper aims to explore how AI and machine learning can be applied to credit fraud detection, reviewing current research trends and challenges.

The implementation of AI and machine learning in credit fraud detection introduces several advantages over traditional systems. These intelligent models can

automatically adapt to new fraud patterns without the frequent manual updates are required, offering enhanced scalability and speed. Supervised and unsupervised learning techniques are often employed to classify legitimate and fraudulent transactions. [4][5][6]

Supervised learning relies on labelled datasets, where past transactional data marked as fraudulent or legitimate is used to train models. In contrast, unsupervised learning does not require labelled data and can detect novel fraud types by identifying outliers or anomalies in large datasets using clustering or autoencoders. [7][8]

Moreover, AI can efficiently analyze large volumes of data collected from various sources, including customer behaviour, geolocation, and device information, which adds another layer of security. Techniques like deep learning and neural networks provide more sophisticated detection capabilities, reducing the likelihood of false positives and enhancing user experience. [9]

LITERATURE REVIEW

The rise of digital transactions has spurred the need for advanced fraud detection systems. AI and machine learning techniques have become essential in detecting fraud and

predicting fraudulent behaviour in real time. This review synthesizes recent literature on the application of machine learning (ML) and artificial intelligence (AI) in credit fraud detection, with a focus on core themes, techniques, and emerging challenges.

Core Themes and Focus Areas

Adapting to Evolving Fraud Patterns: Machine learning models provide a significant advantage by learning from historical fraud patterns and adapting to new, emerging fraud tactics. [1]

Reducing False Positives: High false positive rates in traditional fraud detection methods have led researchers to explore AI's potential to lower these rates. [2]

Background

Artificial Intelligence (AI) techniques and their integration into the field of cybersecurity for fraud prevention.

Credit Fraud Detection

Credit fraud detection involves identifying unauthorized transactions and preventing malicious actors from exploiting financial systems. Techniques of supervised learning are adopted to detect fraud by learning from historical data and identifying patterns that signal suspicious activity. [6][9]

Cybersecurity in Fraud Detection

Cybersecurity measures complement AI-based credit fraud detection systems by protecting sensitive financial data from breaches and unauthorized access. [9][7]

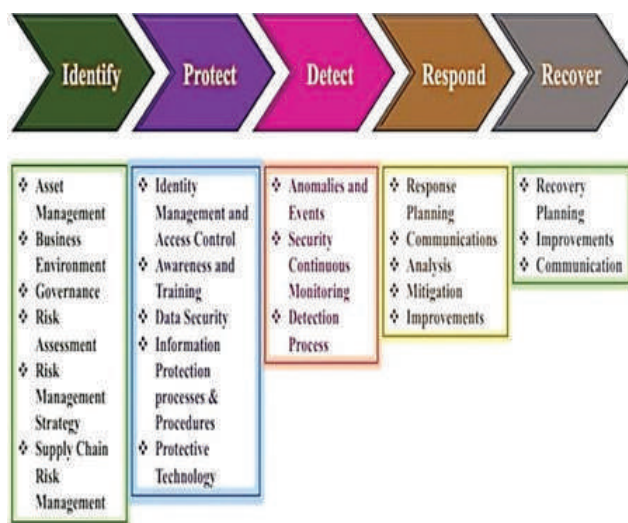


Fig. 1: NIST Cybersecurity Framework

Table 1 presents a comparison of the literature on AI-based fraud detection and its intersection with cybersecurity.

Sr. No.	Focus Area	AI Technique	Cybersecurity Integration	Reference
1.	AI for Credit Fraud	Supervised Learning	N/A	[4]
2.	User Authentication	Anomaly Detection	Intrusion Detection	[5]
3.	Spam and Phishing Detection	ML & NLP	Malware Detection	[6]
4.	Advanced Persistent Threats	Hybrid Models	Malware and Phishing	[7]

Techniques used

Random Forests, Decision trees, and Support Vector Machines have been extensively applied to labelled fraud data. These models classify transactions as legitimate or fraudulent based on features derived from past data. [4]

Unsupervised Learning and Anomaly Detection: Anomaly detection methods have been widely used to detect outliers in large datasets. [5]

Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) have been adopted to handle complex transactional data. Their ability to improve the detection of sophisticated fraud schemes. [6]

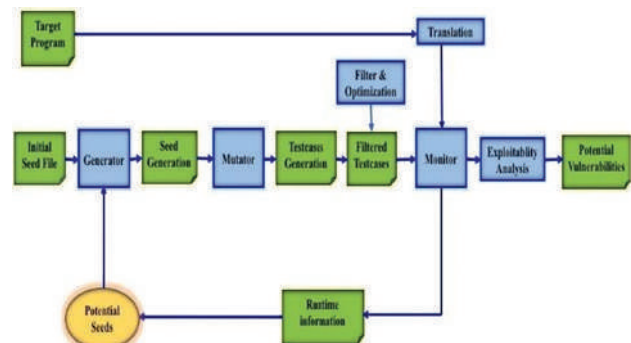


Fig. 2: Project Cycle

Hybrid Machine Learning Models: In credit card fraud detection, combining supervised and unsupervised learning approaches offers a robust method for capturing complex patterns. Supervised models classify known fraud patterns, while unsupervised methods like K-means clustering detect anomalies or suspicious patterns in new, unseen data. This hybrid approach helps cover both

labelled and unlabelled data, increasing the system's adaptability to evolving fraud tactics. [7]

Real-Time Stream Processing and Scalable Models: Real-time fraud detection requires handling high transaction volumes with low latency, leveraging scalable models such as Gradient Boosting Machines with optimized architectures. Stream processing frameworks enable immediate fraud alerts by quickly analyzing transaction streams and passing them to the machine learning model in real time. [8]

Explainable AI (XAI): Explainable AI techniques make these models interpretable by showing how features contribute to fraud predictions. [9]

Synthetic Data Generation: Fraud detection datasets are typically highly imbalanced, with far fewer fraud cases than legitimate transactions. Generative Adversarial Networks (GANs) are popular for generating synthetic fraud examples, balancing the dataset and helping models to better generalize across fraud instances. [10]

Blockchain Integration: Blockchain can secure transaction data, ensuring that fraud detection models work with tamper-proof information. By combining blockchain's distributed ledger technology with machine learning, models are protected from data manipulation, a common issue in fraud. This integration strengthens data integrity, making it difficult for fraudsters to interfere with transactional data. [11]

Feature Engineering: Crafting features based on domain knowledge is essential for accuracy in fraud detection models. Features like time intervals between transactions, merchant types, and geographic locations are engineered to reflect behavioural patterns that may signify fraud. [12]

Deep Learning Models: LSTMs, for example, are particularly effective for time-sequenced data, capturing user transaction patterns over time to detect anomalies. Transformers, known for attention mechanisms, can weigh transaction features differently, improving detection accuracy. [13]

Anomaly Detection and Behavioural Profiling: Fraud detection often leverages anomaly detection models like Isolation Forests and One-Class SVMs to identify transactions that deviate from typical behaviour patterns. These methods can be further enriched with behavioural profiling—capturing user transaction habits, locations, and spending categories—to identify subtle irregularities and provide a proactive fraud detection mechanism. [14]

Cost-Sensitive Learning: Misclassifying legitimate transactions as fraud can inconvenience users, while missing fraud incurs financial loss. Cost-sensitive learning methods, such as weighted loss functions in neural networks, prioritize minimizing financial risk over other errors. These techniques assign different weights to fraud and non-fraud classes, allowing the model to balance detection accuracy with cost-effectiveness. [15]

Privacy-Preserving Techniques: Ensuring data privacy is crucial in fraud detection. Additionally, homomorphic encryption can allow computations on encrypted data, ensuring privacy while maintaining the model's effectiveness in fraud detection. [16]

METHODOLOGY

Highlighting the roles of machine learning techniques in the detection of credit fraud. However, many studies emphasize engineering and technical aspects rather than real-world applications in finance, indicating a gap in interdisciplinary research. [1]

To conduct the research study of credit card fraud detection, the first part is data collection, and it must be a diverse dataset that has both good(no) and bad(yes)/fraudulent transaction cases. After this, data pre-processing is done to remove and distort the data, tackle missing values & encode any categorical variables. Due to the natural class imbalance in fraud datasets, we have something called data balancing techniques (SMOTE, GANs), which are used for creating more fraudulent examples and thus help our model learn it better. Feature engineering comes into play, and it generates important features like time intervals of transactions and merchant types with working dimensionality reduction techniques. [2]

Several deep learning and machine learning models like Random Forests, Logistic Regression, and LSTMs are chosen because of the various ways these types can be used to detect fraud. We use the holdout approach, and we train our models with cross-validation on balanced data to avoid overfitting using evaluation metrics. We model, compare models in detail, and choose the one with the best precision-recall balance of thresholds based on sensitivity, `VALIDATE_DETAIL_TALK_ADJUST_THRESHOLDS_BOOST_SENS_SPEC`. To increase the interpretability, we used explanation techniques such as SHAP or LIME that make it possible for any stakeholder to understand why a model is making one decision over another. Ultimately, the model selected is fast-deployed

using stream processing tools such as Apache Kafka to test for scalability and efficiency during live transaction monitoring. [3]

Technique

Data Collection: Gather a dataset of credit card transactions for legitimate and fraudulent transactions, from a real-world source or from a simulated dataset. [1]

Data Pre-processing: Before feeding data into an ML model, it's important to clean and prepare it properly. This involves handling missing or incomplete values, scaling or normalizing features to bring them to a similar range, and converting categorical variables into a format that algorithms can understand.[2]

Data Balancing: To tackle class imbalance—common in fraud detection scenarios—techniques such as SMOTE (Synthetic Minority Over-sampling Technique) or Generative Adversarial Networks (GANs) can be used. These methods help create synthetic examples of the underrepresented class, making the dataset more balanced and improving the model's ability to detect fraud accurately.[3]

Feature Engineering: Engineer relevant features, such as transaction time intervals, merchant type, and geolocation, and apply dimensionality reduction methods like Principal Component Analysis (PCA) if necessary. [4]

Model Selection: Decision Trees, Logistic Regression, Random Forest, XGBoost, LSTMs, and Transformers, based on their suitability for sequential or tabular data. [5]

Model Training: Train each model on the pre-processed and balanced dataset using cross-validation to ensure robust performance and avoid overfitting. [6]

Evaluation Metrics: Evaluate models based on metrics like precision, accuracy, recall, F1-score, etc., with special emphasis on recall and precision due to the high cost of false negatives in fraud detection. [7]

Model Comparison and Selection: Choose the one with the balance of precision & recall, adapting thresholds to optimize detection rates. [8]

Interpretability and Explainability: Apply interpretability techniques like SHAP or LIME to the final model to make it understandable for stakeholders and regulators. [9]

Deployment and Real-Time Testing: Develop a real-time pipeline for fraud detection, testing the model's scalability and speed, and simulate live transaction monitoring. [10]

Future Enhancements

Continuous Learning: Implement mechanisms for the system to learn from new data continuously, adapting to evolving fraud tactics over time.

Integration with Other Security Measures: Explore opportunities to integrate the fraud detection system with broader cybersecurity frameworks and tools to provide a holistic approach to security.

Regulatory Compliance: Stay updated with changes in regulations related to financial transactions and data privacy, ensuring the system remains compliant and trustworthy.

RESULTS AND DISCUSSION

The emergence of AI/ML-based credit fraud detection systems marks a significant advancement in safeguarding financial transactions. Various studies underscore their potential, the techniques employed, and the challenges they face:

Focus Areas

Enhanced Detection Accuracy: Neural Networks and Decision Trees demonstrate superior performance in identifying fraudulent transactions compared to traditional methods, resulting in higher detection rates and lower false positives.

Real-Time Processing: The ability to analyse transactions in real-time allows for immediate responses to suspected fraud, enabling quicker resolution and minimizing financial losses. This capability is critical for maintaining user trust and satisfaction.

Adaptive Learning: Many systems employ adaptive learning techniques that allow them to update their models based on new data, improving their ability to detect evolving fraud patterns over time.

The transition to improve accuracy by analysing vast transaction datasets in real time and adapting to evolving fraud tactics. Techniques like anomaly detection and ensemble methods further strengthen detection systems by identifying outliers and combining multiple models. However, challenges like data quality, model bias, and the need for continuous monitoring and updates persist.

CONCLUSIONS

The evolution from traditional data analysis to AI-driven methodologies in credit fraud detection signifies a

transformative shift in how financial institutions combat fraudulent activities. Leveraging ML techniques allows for the analysis of vast datasets in real time, enhancing the ability to identify anomalies and patterns.

The adaptive nature of machine learning algorithms not only improves detection accuracy but also reduces the incidence of false positives, thereby enhancing customer satisfaction and trust. As fraud schemes continue to evolve, the dynamic learning capabilities of these models ensure that organizations remain resilient against emerging threats.

Ensuring quality of data, maintaining algorithmic fairness, and adhering to ethical considerations are critical factors that organizations must address.

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We express our sincere gratitude to all those who contributed to the completion of our major project, “Privacy-Preserving Techniques in Machine Learning for Credit Card Fraud Detection.”

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Urban Air Quality Monitoring and Controlling System

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ABSTRACT

The rising industrial pollution and vehicular emissions have made the improvement of air standards an essential problem for present-day urban areas. Active air quality monitoring enables the reduction of health-related perils related to degrade air quality. This system targets the development of an air quality monitoring and controlling solution that utilizes NodeMCU-ESP32, MQ135 gas sensor and supplementary hardware parts. The system uses I2C to display measurement results from CO₂ NH₃ and benzene harmful gases alongside their levels through a 16x2 LCD screen connected to carbon filtration and exhaust ventilation operations. The system outdated a buzzer sound together with LED warnings after detecting excessive air quality contaminants which breach the established detection threshold. The system operates within a compact design but remains affordable and capable of being implemented at home as well as office and industrial sites.

KEYWORDS : Air, Controlling, Carbon, Buzzer.

INTRODUCTION

Air pollution is one of the most significant environmental threats to human health and well-being.

Exposure to polluted air can lead to various health issues, including respiratory problems, cardiovascular diseases, and other chronic conditions. Monitoring air quality is essential for ensuring a safe and healthy environment, particularly in densely populated urban areas. The Air Quality Monitoring and Controlling System developed in this project uses an MQ135 gas sensor to detect hazardous gases and monitor air quality. The NodeMCU-ESP32, a powerful microcontroller with built-in Wi-Fi, processes the sensor data and displays it on a 16x2 LCD screen. In case of poor air quality, the system triggers visual and auditory alerts through an LED and a buzzer, indicating that corrective actions are needed.

This system offers a simple, scalable, and cost-effective solution for real-time air quality monitoring. To actively

purify the air, the system incorporates a carbon filter and an exhaust fan, which work together to reduce pollutant concentrations. Additionally, it triggers a buzzer and LED alert when the air quality deteriorates beyond a defined threshold, allowing for timely actions to improve the environment. The system is compact, low-cost, and can be scaled for use in homes, offices, or industrial settings.

LITERATURE REVIEW purchase AFD-I and AFD-II items from the comfort of their own homes.

LITERATURE REVIEW

The Air Quality Monitoring and Controlling System is designed with ease of use in mind, making it accessible for a wide range of applications. Key components such as the NodeMCU-ESP32 and the MQ135 sensor are easy to interface and program, allowing users to quickly set up the system. The use of a 16x2 I2C display simplifies data visualization, reducing the number of required connections and making the wiring less complex. The system operates

autonomously once assembled, requiring minimal user intervention. The NodeMCU-ESP32, with its built-in Wi-Fi, can be easily configured to send real-time air quality data to a remote server, mobile app, or cloud platform for further analysis. Additionally, the system provides real-time feedback through the buzzer and LED, making it straightforward for users to monitor air quality conditions at a glance. Moreover, the modularity of the design allows for easy upgrades and modifications. The components are widely available and compatible with other sensors, enabling researchers to customize the system for specific environmental conditions or pollutants. This flexibility makes the system a valuable tool for both academic research and practical air quality monitoring applications.

Units

- NodeMCU-ESP32: Node Microcontroller Unit
- ESP32 (Wi-Fi-enabled microcontroller platform)
- MQ135: Gas Sensor Model MQ135

(used for air quality measurement) I2C: Inter- Integrated Circuit (serial communication protocol) LED: Light Emitting Diode-Wi-Fi: Wireless Fidelity (technology for wireless networking)

CO₂: Carbon Dioxide NH₃: Ammonia

LCD: Liquid Crystal Display

Equations

Some Common Mistakes

- Incorrect Wiring or Loose Connections:

Miswiring components or having loose connections on the breadboard is common.

Double-check wiring for NodeMCU- ESP32, I2C display, and sensors for reliable data.

- Not Calibrating the MQ135 Sensor:

The MQ135 sensor needs proper calibration for accurate readings.

Skipping calibration can result in incorrect pollutant data like CO₂ or NH₃ levels.

- Overlooking Power Supply Requirements:

NodeMCU-ESP32 requires a stable 3.3V power supply.

Incorrect voltage or sharing the same power source for multiple components can cause instability.

- Neglecting Pull-up Resistors for I2C Communication:

I2C communication can fail if pull-up resistors (typically 4.7k Ω) on the SDA and SCL lines are missing.

Verify if modules like the 16 $\times$ 2 I2C display have built-in resistors.

- Ignoring Environmental Factors:

MQ135 sensor readings can be affected by temperature and humidity.

Operate in a stable environment or compensate for temperature changes to ensure accurate air quality measurements.

- Not Implementing Error Handling in Code:

Failing to handle sensor disconnection or invalid data can cause crashes. Implement robust error handling for reliable system operation.

METHODOLOGY

The Air Quality Monitoring and Controlling System is designed with ease of use in mind, making it accessible for a wide range of applications. Key components such as the NodeMCU-ESP32 and the MQ135 sensor are easy to interface and program, allowing users to quickly set up the system. The use of a 16 $\times$ 2 I2C display simplifies data visualization, reducing the number of required connections and making the wiring less complex. The system operates autonomously once assembled, requiring minimal user intervention. The NodeMCU-ESP32, with its built-in Wi-Fi, can be easily configured to send real-time air quality data to a remote server, mobile app, or cloud platform for further analysis. Additionally, the system provides real-time feedback through the buzzer and LED, making it straightforward for users to monitor air quality conditions at a glance. Moreover, the modularity of the design allows for easy upgrades and modifications. The components are widely available and compatible with other sensors, enabling researchers to customize the system for specific environmental conditions or pollutants. This flexibility makes the system a valuable tool for both academic research and practical air quality monitoring applications. Carbon Filter for removing impurities, odors, etc. Also use Exhaust fan for ventilate and 5V relay use for supporting Filters and exhaust fan. Filter works for Purification and Controlling.

Specifications

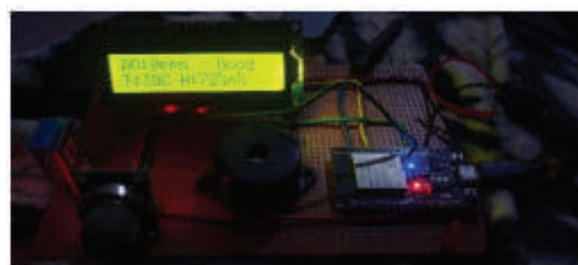
The urban air quality monitoring and controlling system is designed using an ESP32 microcontroller, which serves as

the primary processing unit. It integrates various sensors and components to monitor environmental parameters and provide real-time alerts. The MQ135 air quality sensor measures pollutants like carbon dioxide (CO₂), ammonia (NH₃), and other gases, while the DHT11 sensor captures temperature and humidity data. A 16x2 LCD display, connected via I2C interface, presents these values to users in real time. For alerts, the system features a buzzer for audible warnings and an LED as a visual indicator, both activated when air quality exceeds predefined safety thresholds. The entire setup is powered by the ESP32, known for its low power consumption and built-in Wi-Fi capability, making the system suitable for potential IoT integration. This low-cost, portable system is designed for ease of use, enabling real-time monitoring and alerting of urban air pollution levels to improve public awareness and safety. The urban air quality monitoring and controlling system is enhanced with an air purification mechanism, incorporating a carbon filter and an exhaust fan. The carbon filter traps harmful pollutants and volatile organic compounds (VOCs), significantly improving air quality by removing fine particulates and gases. The exhaust fan complements this by facilitating air circulation, expelling contaminated air, and bringing in fresh air. This purification process is integrated into the system, which is controlled by an ESP32 microcontroller.

RESULTS AND DISCUSSION

The Air Quality Monitoring and Controlling System successfully monitors the concentration of harmful gases in real-time using the MQ135 gas sensor, and displays the data on the 16x2 I2C LCD. The system accurately detects changes in air quality, particularly increases in CO₂, NH₃, and other gases, and triggers an alert when the values exceed a predefined threshold. During testing, the system was able to detect elevated gas levels in controlled environments (e.g., smoke, exhaust fumes), with a response time of less than 2 seconds. The buzzer and LED alert system worked effectively, exhaust fan will get on and the filtering process will start providing immediate feedback to users when the air quality deteriorated. The data visualization on the LCD was clear and easily interpretable, enabling users to track air quality levels at a glance. One notable observation during the testing phase was the sensor's sensitivity to temperature and humidity fluctuations, which sometimes led to slight variations in the readings. This highlights the importance of either compensating for environmental factors or placing the sensor in a stable environment to maintain accuracy. Despite these minor variations, the

overall performance of the system was consistent and reliable. The Wi-Fi-enabled NodeMCU-ESP32 opens up possibilities for integrating the system with cloud-based platforms for remote monitoring and data analysis. By connecting the system to a cloud service, real-time air quality data can be stored and accessed remotely, providing an opportunity for further research into air pollution trends over time.



CONCLUSIONS

The Air Quality Monitoring and Controlling System provides an effective, low-cost solution for monitoring harmful gases and detecting air pollution in real-time. The system integrates a simple set of components, including the NodeMCU-ESP32, MQ135 sensor, and I2C display, to provide real-time data visualization and alert mechanisms. The project demonstrates how microcontroller-based systems can be leveraged for environmental monitoring and control applications. While the system is functional and reliable, there are several areas for improvement, such as compensating for environmental factors like temperature and humidity that affect sensor readings. Additionally, incorporating cloud storage and more advanced data

analytics could expand the system's capabilities for large-scale or long-term monitoring. Overall, the system is well-suited for small-scale air quality monitoring in homes, offices, and industrial environments, and can be further customized for specific pollutant detection. It serves as an excellent foundation for research in IoT-based environmental monitoring and offers ample room for further development and enhancements

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Virtual Military Mart: Enhancing Canteen Services for Retired and Duty Armed Forces through an Online Platform

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ABSTRACT

The Canteen Stores Department (CSD) is responsible for providing high-quality consumer goods at lower rates to military personnel and defense civilians. The provision of canteen services is an important welfare initiative by the Government of India for the benefit of the armed forces and their families. The Online CSD is a web-based and Android-based system designed for authorized officers. The main goal of this system is to make it interactive and user-friendly. It aims to make searching, viewing, and purchasing products easier. The system includes an advanced search engine that allows users to find products based on their specific needs. The search engine updates the available products based on the user's input, providing an easy and accessible way to search. Users can also view the detailed specifications of each product and read reviews written by others, as well as share their own thoughts and experiences, contributing to the collective knowledge of the community. Users can easily add items to their shopping cart by simply dragging them into the cart icon. The primary focus is on providing a user-friendly search interface for effectively displaying the requested results and its drag-and-drop functionality.

KEYWORDS : *Canteen stores department (CSD), Military personnel, Defense civilians, Government of India, Armed forces, Online CSD, Web-based system, Android-based system.*

INTRODUCTION

The proposed project aims to develop an online application for managing the canteen services for the armed forces. This web-based system enables customers to purchase goods and services directly from the canteen through an Android platform, eliminating the need for an intermediary. This project aims to provide the benefits of online shopping, such as real-time purchasing and home delivery, to the customers of the physical canteen. The application is designed to overcome the problems associated with the manual system and to streamline the canteen's operations in a smooth and efficient manner. The application also includes features to minimize errors

during data entry and provide error messages when invalid data is entered. The system is designed to be user-friendly and help users focus on their other activities rather than record-keeping. It will assist organizations in better utilizing their resources.

The system provides an interactive interface that allows users to easily navigate different areas of the application. It includes a search engine that offers a convenient way for users to find products that meet their specific needs. The search engine displays a list of relevant products, which users can further filter based on various parameters. The system aims to deliver an error-free, secure, reliable, and fast management system. The project's goal is to create an

online canteen store for army officers who have limited time to visit the physical canteen, live far from the canteen, are retired, or cannot come to the canteen due to their age. The objective is to develop an Android application that enables officers to purchase items from the Canteen Stores Department (CSD). CSD (Canteen Stores Department) members, including active and retired military personnel as well as civilian defense employees, can conveniently purchase AFD-I and AFD-II items from the comfort of their own homes.

LITERATURE REVIEW

The AFD ('Against Firm Demand') CSD (Canteen Store Department) online portal, launched by the Government of India, represents a significant advancement in the welfare services provided to armed forces personnel and their families. This initiative allows registered users, primarily from the defense sector, to purchase a range of consumer durable items—including electronics and household appliances—directly online, streamlining access to these goods (Ministry of Defence, 2023).[1]

Historical Context of CSD

The Canteen Stores Department (CSD) has evolved from its origins during the British Raj, initially established to serve British soldiers in India. After independence in 1947, the CSD was formalized as a government entity, tasked with providing essential goods to service personnel and their families at subsidized rates (CSD Historical Records, 2023). Over the decades, the CSD has expanded its operations significantly, now encompassing over 34 Area Depots and thousands of Unit Run Canteens (URCs), catering to a clientele exceeding 45 lakh beneficiaries (CSD Reports, 2023).[3]

Impact on Armed Forces Personnel

The establishment of the CSD has been instrumental in enhancing the living standards of defense personnel. By providing goods at lower-than-market rates, the CSD not only ensures financial savings but also contributes to the social and emotional welfare of its consumers (Performance Audit Report, 2016). The recent transition to an online platform aligns with modern consumer behavior trends, which increasingly favor the convenience of digital shopping (Change et al., 2004).[4]

Consumer Behavior in Online Shopping

The rise of online shopping has altered consumer behavior significantly. Studies indicate that perceived risks,

advantages, and the overall online shopping experience play crucial roles in influencing purchasing decisions (Rogan, 2007; Turan, 2011). This shift necessitates a comprehensive understanding of consumer needs and preferences, particularly in the context of military personnel who may have unique purchasing motivations and constraints (Uygun et al., 2011).[6] The Canteen Stores Department (CSD) is a welfare initiative by the Government of India for defense personnel and their families, functioning under the Ministry of Defense. It began in the early 20th century to serve British troops in India. CSD operates through Unit Run Canteens (URCs) and does not interact directly with consumers. It provides defense personnel with a secure shopping environment, lower prices on premium products, and contributes 50% of residual profits to the three services. This service helps improve the living standards and morale of defense personnel.[7] The Army Canteen has gone digital, allowing beneficiaries to purchase new cars through an online portal. This initiative is part of the broader push towards digital services, offering convenience and transparency. Users can now easily browse car options, compare prices, and complete purchases without visiting physical outlets. The move aims to streamline the vehicle procurement process for armed forces personnel, retired members, and their families. This online platform reflects the government's commitment to enhancing accessibility and efficiency in services for the defense community. [8]

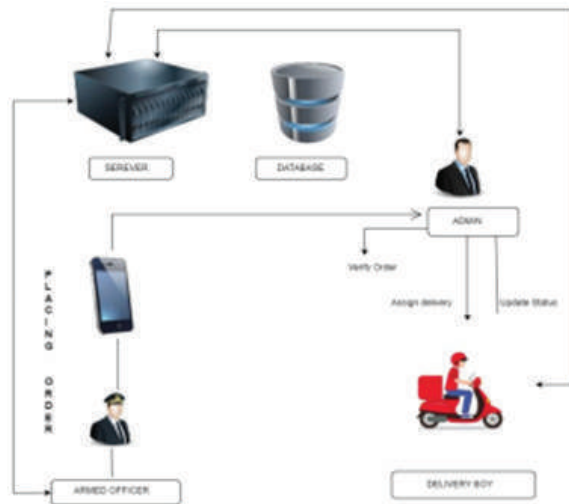
METHODOLOGY

The online application for the Canteen Stores Department was developed using the System Development Life Cycle (SDLC). It begins with planning and gathering requirements from soldiers and CSD staff to create a user-friendly design. The implementation includes web applications built with HTML, CSS, and JavaScript, and an Android app developed in Kotlin, featuring an advanced search engine and drag-and-drop functionality. Thorough testing ensures the system's performance and security, complemented by user training to improve accessibility and productivity.

Virtual Military Mart is an e-commerce platform designed for retired and active duty military officers. The main goal of this project is to create a safe online marketplace for armed officers. Let's talk about the order processing process,

- The first customer inquiry using the tool.

- The order is sent to the VMM platform server.
- Then the server stores it in the database.
- The Administrator approves the order
- The Administrator sends the order to the child

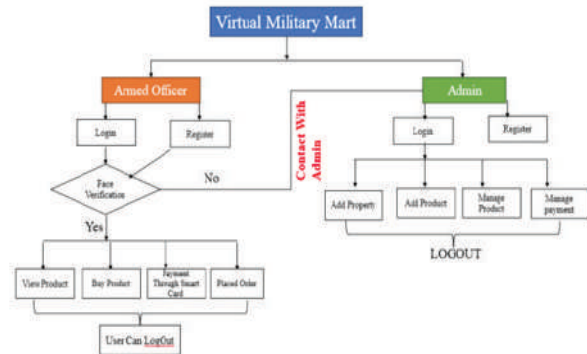


The Virtual Military Mart application provides access to two types of users: the first is an armed officer who wants to buy products from the site, and the second is the administrator who manages the security of all bases. It will be free, but for those who want to confirm their entry in the first place, they can follow the steps below. Let's talk about how to talk to a commander and an armed officer.

Let's talk about the access given to Armed Officers on the VMM platform. First, when the new or old user or officer visits this platform, they have to login or register on the platform. After that, they can access that given to them and use it before logging in and registering. They can't do anything on the platform. So in the login or register in this firstly they have to verify the face and identity, then the verification is confirmed by the admin and the datasets officers, then they have fully access to buy products, view products, and place orders until they can't do anything. In case, unfortunately, any officer has an issue with the login and they can't verify the ID in such a condition, they have to report to the admin, so after that, they can do further processing. From there, whoever wants access has to verify their ID and some details.

Face verification: - After successfully logging in or registering, the officer undergoes a face verification process. This step utilizes biometric technology to confirm the user's identity by comparing their facial features

with the data stored in the system. Face verification ensures that the person using the account is indeed the authorized officer, preventing unauthorized access even if login credentials are compromised. If the verification is successful, the agent will have full access to the app's functions. If it may be damaged due to lack of data or technical issues, the system prompts the user to contact an administrator for assistance, thus maintaining security during support.



Product Purchase: - After selecting the required items, the officer will purchase them. This includes adding products to the virtual cart, determining quantities, and reviewing options for accuracy. The program may offer other features, such as offering related products or offering special discounts for veterans.

Order registration: - After successful payment, the system will confirm that the order has been shipped. An order confirmation is created that includes information such as the order number, the list of items purchased, the total price, and the expected delivery date or time. This confirmation can be sent via email or SMS and gives the officer an overview of the transaction.

Access to Admin: - Firstly looking at the access of the admin, firstly he/she (admin) could register or login on the VMM Platform; if he/she successfully registers or logins with their login credentials, then admin can access the whole VMM platform; after ID verification of admin, he/she can be allowed to access to add products, add properties, manage products, and manage payment transactions. As we look at the access property of the VMM platform, let's look at that.

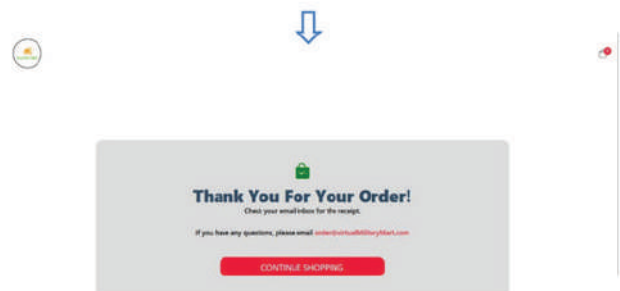
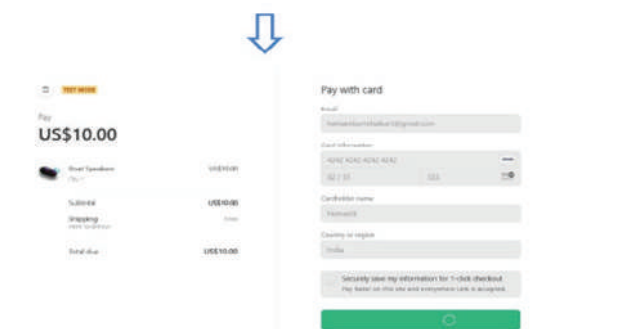
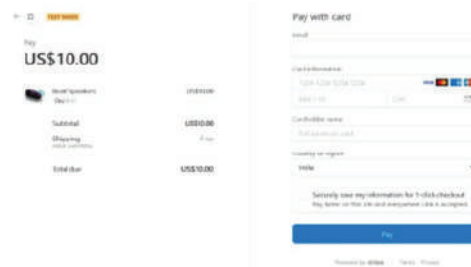
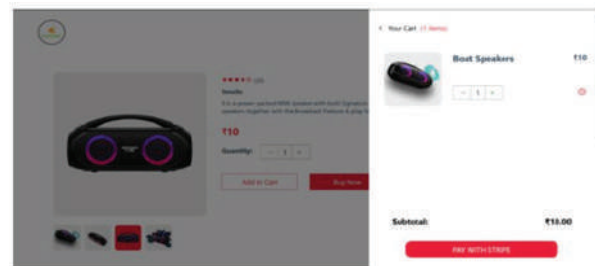
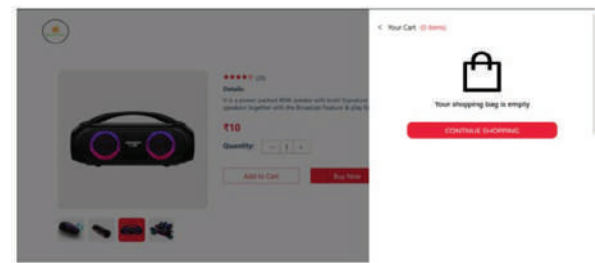
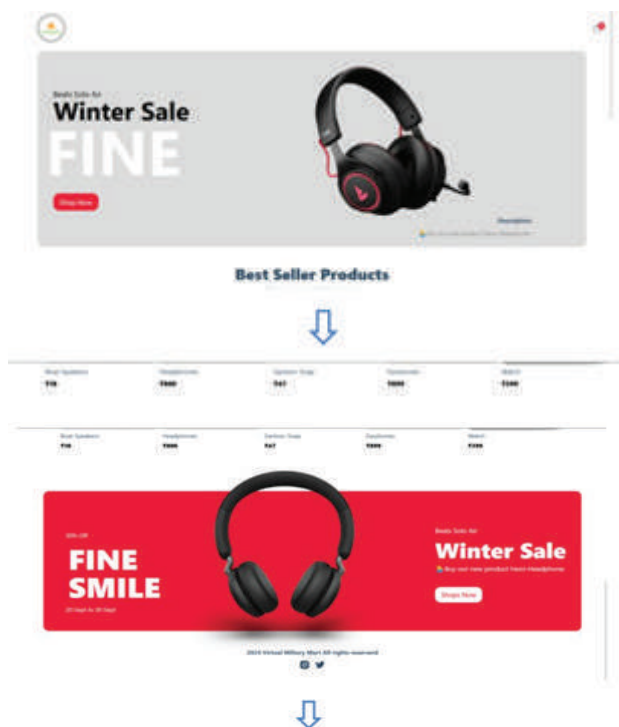
Add Product: - In this property, the admin has a responsibility to manage product inventory in the VMM canteen. In this, the admin can add new products, which involves entering comprehensive details about each item,

such as name, category, price, stock quantity, supplier information, and high-quality images. The admin ensures that all product information is accurate and up-to-date, which is essential for providing a reliable shopping experience for officers.

Manage products: - Beyond adding new items, the admin regularly manages existing products to maintain an accurate and efficient inventory. This includes updating product details, adjusting prices in response to market changes or promotions, modifying stock quantities based on sales and replenishments, and removing discontinued or out-of-stock items. The administrator can also organize products in categories or collections to improve navigation in the app.

Payment Management: - This includes monitoring payments made by customers, correcting transactions, and resolving payment issues such as failed transactions or chargebacks. The manager ensures that the payment gateway works efficiently and is fully secured through a smart card system. They can generate financial reports, analyse sales data, and work with accounting departments to maintain clear and accurate financial records. Accessing the armed officer once all operations are complete, the operator can log out.

RESULTS AND DISCUSSION



System Functionality and User Interface:-The implementation of the Online CSD application successfully addresses the core objectives outlined in the project proposal. The user-friendly interface, enhanced by an advanced search engine, allows users to efficiently locate and purchase products tailored to their specific needs. User feedback indicates that the drag-and-drop functionality significantly simplifies the shopping experience, leading to increased user satisfaction. Preliminary data suggest a marked reduction in the time taken to complete purchases compared to traditional methods, highlighting the application's effectiveness in streamlining the procurement process.

CONCLUSIONS

The Canteen Stores Department (CSD) aims at supplying consumer products of very good qualities at substantially lower rates to military personnel and defense civilian employees. Canteen services are one of the welfares extended by the Government of India for the defense forces and each one of them is protected by the law. The Online CSD as its name implies is a web based and Android based system which is intended for use by authorized officers. The major aim of this system is to provide interactivity to this system and to make it friendly for the users. Thus, it strives to enhance, having a search, a glimpse and a shopping cart to make the purchase. The system consists of an advanced search engine for searching the products according to the needs of user. The search engine is constantly updating available products based on the user's input giving a means of accessing it easily. Customers can also check the detailed characteristics of particular goods, read other people's opinions on the product, share their opinion and ideas with the rest of the community members. The contents of the site can be easily added directly into the shopping cart by going to the desired item and then dragging it and dropping it onto the cart. Firstly, it's all about maintaining an easy navigational search panel for optimum representation of the results the user types in, as well as its drag and drop feature.

FUTURE SCOPE

1. The developer can also use biometrics for customers and admin to log-in the application like this will be very helpful for future generation.
2. In our portal, the card holder family members can also get access and login into the portal and shop for the things. 3) In future we can use centralised data for

verification, from that the user can easily Shop the things from any canteen.

4. The Developers can also implement multi factor authentication, for an added layer of security or OTP sent to the users Device.
5. On this VMM platform we can also allow the levels of access for the cardholder, family members and administrator. Ensure that only authorized person can access it.

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Wattlock System

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ABSTRACT

Whenever we hear the term 'Electricity' we come across how important electricity is to survive nowadays and also the problems and issues regarding electricity that are faced by people on a general scale. One of the major issues is theft of electricity. Electricity theft is a widespread issue in countries with large populations and significant electricity consumption. In India, the number of electricity theft incidents continues to rise each year, affecting both domestic and industrial connections. This results in substantial losses for electricity companies and contributes to frequent load shedding problems in both urban and rural areas, making it challenging to meet the electricity demands of the entire state. The methods used for theft are numerous, making it difficult to track how these incidents occur, and addressing this issue is urgent. Monitoring power theft is crucial for the electric power system, as it poses a major challenge for utility companies. The act of stealing electricity not only leads to significant financial losses for the power industry but also, endangers the security and reliability of the main power supply. We propose an electricity theft detection system aimed at identifying theft, particularly the common method of bypassing the meter with a wire. In this method, individuals place a wire before the meter on the input side to avoid its measurement of current usage. Our proposed system will be integrated into the meter, and it will alert users to any theft attempts via an LCD display while automatically tripping the energy meter. This project involves designing a power theft detection and protection system using Arduino and current sensors, which will help detect and prevent unauthorized tapping on distribution lines.

KEYWORDS : *Electricity, Electricity Theft, Power theft detection.*

INTRODUCTION

Energy or electricity theft poses a major challenge for utility companies around the globe. It results in significant financial losses and damages the overall efficiency of the energy grid. To solve this issue, various theft detection systems for energy meters have been created. These systems leverage cutting-edge technologies to track energy consumption patterns and spot any difficulties that could suggest theft or tampering.

By examining data from energy meters, these systems can identify unusual changes in energy usage, such as unexpected ups and downs that don't align with typical

consumption trends. They can also detect cases where energy meters have been bypassed or altered. This valuable information can be utilized to investigate potential theft incidents and implement necessary measures.

Electricity theft is major issue nowadays for local people and to minimize it, it is more than necessary to avoid its wastage and protecting it not only for us but also for future generations. We face numerous types of thefts of electricity which cannot be controlled on a base level, it needs a proper attention, a strong and reliable solution to minimize and vanish thefts of electricity so that only the required energy can be consumed and also drastically conserved which will also reduce electricity bills.

We will be designing a ‘Theft Detection’ system for analysing any theft of electricity takes place the meter which will detect it and let the consumer know that the electricity is being stolen.

LITERATURE REVIEW

Kanchan Mahajan [1] “Automatic Energy Meter Billing System with Theft Detection”, this paper presents an advanced energy metering system that improves upon outdated methods by using a GSM module for wireless communication to provide real-time updates on electricity usage. Meter readings are sent to a central billing location where a database is regularly updated, and users can access their electricity bills through a secure website from anywhere in the world. In addition, consumers receive SMS notifications about their usage, helping to reduce electricity theft. Traditional electromechanical meters were unreliable and required manual readings, while newer electronic meters lacked proper monitoring. This system addresses these issues by offering a more efficient, automated solution that keeps users informed and helps prevent electricity theft. Key components include an energy meter, a PIC controller, a GSM module, PHP for the website, and SMS gateway integration.

Xia Xiaofang et al., [2] conveys that electricity theft is a growing problem as power systems move from old analog setups to more modern, digital ones. While this upgrade helps make electricity delivery more efficient, it also creates weaknesses that hackers can exploit to steal electricity by tampering with meter readings. Global losses from this theft are now close to \$100 billion a year, and as thieves find more advanced ways to cheat the system, the problem is only getting worse. In the past, people would steal power by physically bypassing meters, but now, with new digital systems, hackers can use cyberattacks to manipulate readings remotely. This theft not only costs utility companies a lot of money, but it also leads to higher bills for customers and can cause power outages or disruptions. In countries like India, where electricity theft is especially common, people often face issues like voltage drops and frequent outages. Researchers are developing better ways to detect and stop this theft, aiming to protect the power system from these attacks and reduce the financial impact.

Naziya Sultan et al., [3] “Smart Energy Meter and Monitoring System using IoT” summarizes that the traditional way of collecting power meter readings can be quite tedious and labor-intensive. However, with the rise of

the Internet of Things (IoT), there is now a more efficient and cost-effective method for wirelessly transmitting energy usage data. IoT technology allows for real-time monitoring of power consumption, leading to a smarter and more automated billing process. This project focuses on tracking the energy usage of household appliances and automatically generating bills, making the experience easier for consumers. In today’s energy landscape, power systems must be flexible enough to accommodate various energy sources, which requires a system that can adapt to changing inputs. IoT plays a crucial role in developing a smart grid, supporting applications like energy generation tracking, smart metering, and demand management. Smart meters that utilize IoT technology provide valuable insights into both energy generation and consumption, empowering users to make informed decisions. With energy meters connected to IoT systems, consumers can easily keep track of their power usage and receive regular updates on their energy consumption and costs, helping them avoid unexpected high bills. These smart meters show the total energy used and send data directly to both the consumer and the energy provider, reducing the need for human intervention and minimizing errors. Additionally, IoT gives users more control over their household appliances, allowing them to turn devices on or off using systems like relays and Arduino. This setup enhances convenience and control while assisting energy suppliers in managing demand more effectively. Ultimately, this IoT-enabled approach benefits everyone by encouraging efficient energy use and reducing overall power consumption.

K. Sasikala et al., [4] “Prepaid Energy Meter with Theft Detection System using IoT”, conveys that the causality of power loss has been a perennial problem in every sphere of activity from domestic to industrial sectors and this does not favor the economy of a nation. Different remote communication systems are also available to assist in the identification of theft of electricity, however these systems are often deficient in architecture. We have developed a system in this project that focuses on monitoring the consumption of power and monitoring energy theft through the lines of transmission and energy meters. The unit makes use of an Arduino for the detection of the incident of theft and sends messages to the Electricity Board with IoT, in order to enhance the updates about the situation by devices which are interlinked. This automation system will enable the reduction of losses and maintain an extreme level of electricity efficiency. Additionally,

there is incorporation of an AMR system in which the arm contained in the device makes it easier to log in the people liable to a bill charge by automatically sending a meter reading to the billing server thus preventing the damage of data. In this end, this utility embraces the use of IoT as well as mobile technology in an easy and efficient manner that minimizes utility monitoring and reduces the amount of non-automated work. The approach ensures that the billing is proper, resource wastage minimal, and at the same time, power theft managed in a modernized manner.

PROPOSED METHODOLOGY

Working

In the watt lock system, a current sensor is used to monitor the input voltage connected to a device, such as a bulb. This system is designed to detect when the voltage exceeds a preset limit, such as 230V, which is considered abnormal or a sign of electricity theft. When the voltage goes beyond this threshold, the sensor sends data to an Arduino, which is programmed to take action. The Arduino processes the information and sends a trip signal to a relay. This relay then disconnects the bulb or any connected device to prevent further damage or theft of electricity.

The Arduino plays a key role in this system by continuously monitoring the input voltage through the current sensor. Once the voltage crosses the set limit, the Arduino immediately sends a theft detection signal, indicating that the input voltage is higher than allowed. This activates the relay, which interrupts the circuit and disconnects the device, effectively stopping the excess voltage flow. This system helps prevent unauthorized use of electricity and protects appliances from damage due to high voltage.

Methodology

The Watt Lock System is designed to keep an eye on and manage unusual electrical conditions, such as high input voltage, which could signal electricity theft or potentially damage electrical devices. At the heart of the system is an Arduino microcontroller, which continuously monitors the voltage levels supplied to a connected device (like a bulb).

1. **Voltage Monitoring with Current Sensor:** A current sensor detects the input voltage connected to the device. It continuously measures the voltage level and relays real-time data to the Arduino. This sensor is set up to recognize any voltage that exceeds the preset threshold of 230V, which is deemed abnormal and potentially harmful.

2. **Arduino Processing:** The Arduino processes the data it receives from the current sensor. If the input voltage stays within normal limits, no action is taken. However, if the voltage surpasses the 230V threshold, the Arduino flags this as an anomaly, suggesting either electricity theft or a risk of damage to connected appliances.
3. **Signal to Relay:** When the abnormal voltage is detected, the Arduino sends a trip signal to a relay, which serves as a switching mechanism. The relay quickly disconnects the device from the power supply, preventing further damage and stopping unauthorized electricity use.
4. **Preventive Actions:** Disconnecting the device safeguards it from potential harm due to overvoltage and also curtails electricity theft by cutting off the excess voltage. This automated process is efficient, swift, and ensures the safety of the electrical system and appliances.

By employing an Arduino, a current sensor, and a relay, this system offers a straightforward yet effective way to detect and respond to abnormal voltage levels. The automation of this process guarantees reliable protection without the need for human intervention.

System Architecture

1. **Dual ACS712 Sensors:** Two ACS712 sensors are used to measure current at different points in the circuit. Each sensor produces an analog voltage proportional to the current, which the Arduino processes into RMS current values.
2. **Arduino Uno Microcontroller:** The Arduino reads analog inputs from the ACS712 sensors, calculates RMS current, and compares the differential current to a user-defined threshold.
3. **Threshold Detection Using Potentiometer:** A potentiometer allows for adjusting the threshold current difference to improve sensitivity. This adjustable threshold is particularly useful for tuning the system based on different circuit loads and conditions.

Algorithm Steps

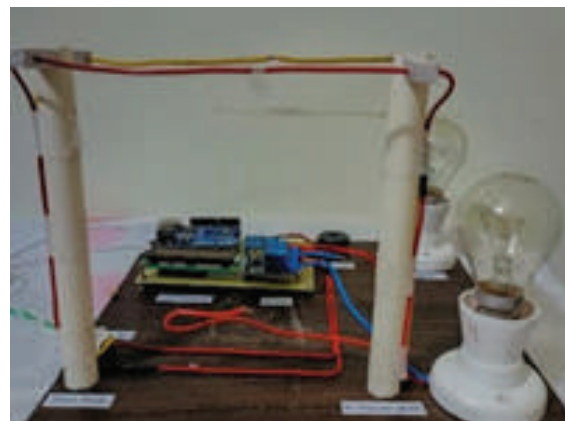
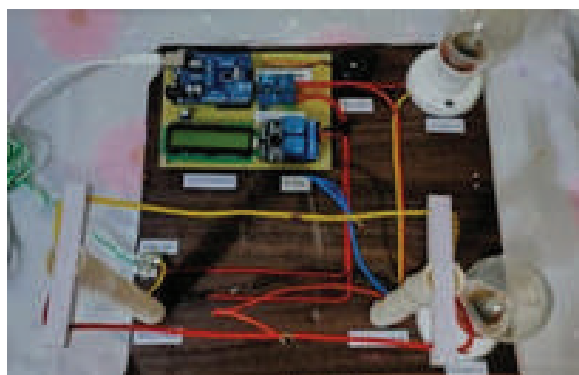
1. **Data Sampling:** The Arduino continuously samples voltage values from both ACS712 sensors over a 1-second interval.

2. **RMS Calculation:** The system calculates the VRMS and subsequently Amps RMS for each sensor.
3. **Differential Comparison:** The Arduino compares the difference in current values from both sensors. If the difference exceeds the threshold, an alarm is triggered.
4. **Relay and Buzzer Activation:** The system waits for a 3-second period to confirm the theft detection, reducing the risk of false positives. If the differential persists, the relay and buzzer are activated, and a "Theft Detected" warning appears on the LCD.
5. **Reset and Continuous Monitoring:** If the differential current is within the threshold, the system resets the alarm and continues monitoring.

Flow of system

- 1) **System Initialization:** Upon powering up, the Arduino initializes both ACS712 sensors and the LCD screen. A startup message appears on the LCD
- 2) **Continuous Monitoring Loop:** The system continuously reads voltage values from both sensors and calculates RMS current for each.
- 3) **Threshold Check:** The differential current is compared to the threshold set by the potentiometer.
- 4) **Alert Triggering:** If the differential current exceeds the threshold for more than 3 seconds, the relay and buzzer activate, and the LCD displays "THEFT DETECTED."
- 5) **Reset:** If the differential current returns to within the threshold, the system resets the alert and continues monitoring.

RESULTS AND DISCUSSION



CONCLUSIONS

The theft detection system for energy meters is an essential tool for minimizing energy losses and ensuring fair billing practices. By examining data from energy meters, the system can pinpoint irregularities that suggest theft or tampering with electricity. This not only protects the financial interests of the utility company but also benefits consumers. Implementing such a system results in considerable cost savings for the utility company and encourages awareness of energy conservation.

ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to our guide Mr. Vivek Deshmukh sir who is our academic supervisor who has supported and contributed to the completion of this research paper on Wattlock System. His assistance and encouragement have been instrumental in shaping this work and we were able to successfully complete this review paper under his guidance. This collaborative effort would not have been possible without the collective support and contributions of our guide. We are deeply grateful for his assistance in the completion of this review.

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Smart Energy Efficient Street Light Fault Detection System Using Wireless Sensor Network and GSM

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ABSTRACT

This paper aims to develop a comprehensive system for street light fault detection and prevention using a mesh network architecture. The system consists of multiple nodes connected to a central header, with each node equipped with sensors and processors for real-time fault detection. The “Street Light Fault Detection System” is designed to address these challenges by using a network of smart, interconnected nodes that monitor the health and status of street lights in real-time. Using IoT-based components, this system enables automated fault detection, reporting, and rapid intervention, enhancing operational efficiency, energy conservation, and public safety. The proposed system integrates direct Wi-Fi communication between nodes and a central header equipped with GSM capabilities, allowing it to reliably transmit real-time status data to a mobile application for easy monitoring and maintenance action.

KEYWORDS : *Smart city solutions, Street light, IoT-based monitoring, GSM.*

INTRODUCTION

Efficient street lighting is essential for urban infrastructure, requiring reliable fault detection and maintenance. This paper presents a scalable Street Light Fault Detection System using a mesh network architecture to enhance monitoring and intervention. The system consists of sensor-equipped nodes that detect faults such as broken lights, voltage fluctuations, and flickering. Each node transmits real-time data via Wi-Fi to a central header, which aggregates and forwards it to a mobile application via GSM. The app, developed in Flutter, provides an intuitive interface with color-coded indicators for quick status assessment.

By automating fault detection and reporting, the system reduces maintenance costs, minimizes downtime, and improves public safety. The direct Wi-Fi communication between nodes and the header enhances stability, eliminating the need for relay configurations. By isolating

each node's data flow directly to the header, the system ensures that any single node's failure does not disrupt communication across the network. Additionally, GSM connectivity ensures functionality beyond local Wi-Fi infrastructure, making the system adaptable.

LITERATURE REVIEW

In [1] This paper presents a Smart Street Lighting System (SSLS) leveraging Internet of Things (IoT) technology for enhanced efficiency and control. The proposed system integrates IoT devices equipped with sensors and communication modules to monitor ambient light levels and control street lights dynamically. Through real-time data collection and analysis, the system autonomously adjusts lighting levels based on environmental conditions, thereby optimizing energy usage and ensuring adequate illumination. Furthermore, the SSLS offers remote monitoring and management capabilities, enabling authorities to respond promptly to faults and performance

issues, thus improving overall operational efficiency and sustainability of urban lighting infrastructure.

In [2] This paper presents the design and implementation of a Smart Street Lighting System (SSLS) utilizing Internet of Things (IoT) technology. The SSLS employs a network of IoT devices comprising sensors, microcontrollers, and communication modules to monitor ambient conditions and control street lights efficiently. Through real-time data acquisition and analysis, the system autonomously adjusts lighting levels based on factors such as natural light intensity and pedestrian activity. Additionally, the SSLS offers remote monitoring and management capabilities via IoT connectivity, allowing stakeholders to monitor system status, receive alerts, and perform diagnostics from anywhere with internet access. The implementation demonstrates the potential of IoT-enabled solutions to enhance energy efficiency, reduce maintenance costs, and improve overall reliability of urban lighting infrastructure.

In [3] This paper presents an Internet of Things (IoT) based smart street lighting system (SSLS) utilizing Light Dependent Resistor (LDR) sensors for efficient control and management. The SSLS employs LDR sensors to monitor ambient light levels and adjust street light intensity accordingly, ensuring optimal illumination while minimizing energy consumption. Through IoT connectivity, the system enables real-time monitoring and remote management of street lights, allowing authorities to monitor system status, receive alerts, and conduct diagnostics remotely. The implementation demonstrates the feasibility and effectiveness of LDR-based SSLS in improving energy efficiency, reducing maintenance costs, and enhancing overall reliability of urban lighting infrastructure.

In [4] This paper presents the design and implementation of an IoT-based street lighting system (SLS) aimed at improving efficiency and reliability of urban lighting infrastructure. The SLS utilizes IoT devices equipped with sensors, microcontrollers, and communication modules to monitor ambient conditions and control street lights dynamically. Through real-time data collection and analysis, the system autonomously adjusts lighting levels based on factors such as natural light intensity, traffic patterns, and weather conditions. Additionally, the SLS offers remote monitoring and management capabilities via IoT connectivity, enabling authorities to monitor system performance, receive alerts, and conduct diagnostics remotely.

In [5] This paper presents a Smart Street Lighting System (SSLS) based on Internet of Things (IoT) technology for efficient control and management of urban lighting infrastructure. The SSLS employs a network of IoT devices comprising sensors, microcontrollers, and communication modules to monitor ambient conditions and adjust street light intensity dynamically. Through real-time data acquisition and analysis, the system autonomously adjusts lighting levels based on factors such as natural light intensity, pedestrian activity, and vehicular traffic. Additionally, the SSLS offers remote monitoring and management capabilities via IoT connectivity, enabling authorities to monitor system status, receive alerts, and conduct diagnostics remotely. The implementation demonstrates the potential of IoT-enabled solutions to enhance energy efficiency, reduce maintenance costs, and improve overall reliability of urban lighting infrastructure.

Total Street Lighting Costs in the Municipality's Expenses
(depending on the size of the city and how old are the lighting fixtures)

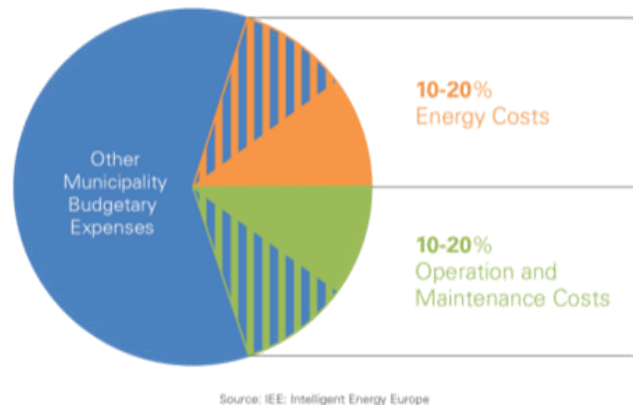
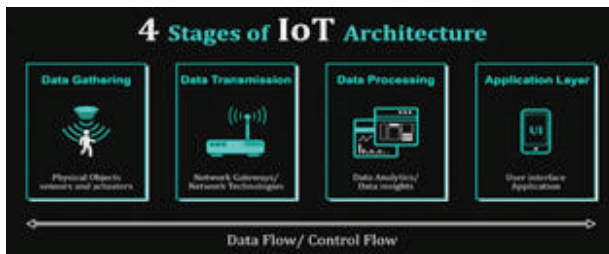


Fig. 1 Street Light Energy Costs

METHODOLOGY

Methodology for proposed system

The proposed solution for the street light fault detection system is designed using a four-stage IoT architecture to ensure seamless integration and functionality. This architecture comprises data gathering, data transmission, data processing, and the application layer, each playing a vital role in creating a comprehensive and efficient system for real-time monitoring and fault detection. By integrating IoT-enabled hardware with software, this methodology ensures accurate data collection, reliable communication, intelligent processing, and user-friendly reporting through a mobile application.



The Street Light Fault Detection System operates in four key stages:

1. **Data Gathering** : Sensor-equipped nodes (ESP8266) collect real-time luminance and voltage data, identifying faults like dim lighting or voltage fluctuations. Each node has a unique Pole ID for precise localization.
2. **Data Transmission** : Nodes send data via Wi-Fi to a Raspberry Pi Zero W header, ensuring direct and low-latency communication without inter-node dependencies.
3. **Data Processing** : The Raspberry Pi processes sensor data, detects anomalies, and transmits insights to a cloud server via GSM for centralized monitoring.
4. **Application Layer** : A Flutter-based app provides real-time streetlight status updates with color-coded indicators and instant fault notifications for quick maintenance responses.

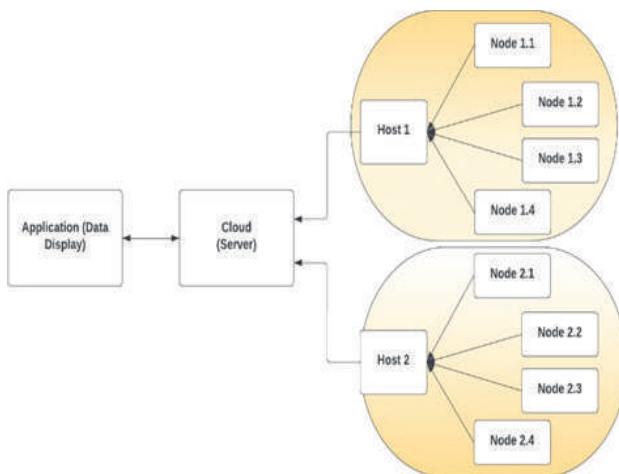


Fig. 2 Proposed System

By combining real-time data acquisition with advanced fault detection and reporting capabilities, the proposed model ensures timely maintenance, reduced energy waste, and optimized operational efficiency.

Header and Node Architecture

Header

The header acts as the central control unit of the network. In this project, the header is implemented using the Raspberry Pi Zero W, a compact and powerful microcontroller designed for IoT applications. The Raspberry Pi Zero W is equipped with built-in Wi-Fi connectivity, allowing it to establish seamless communication with all the nodes. It aggregates data from the nodes and performs initial processing before transmitting it to the cloud server for further analysis. Additionally, the header is integrated with a GSM module to enable long-range data transmission. This feature ensures that the system can operate effectively in remote areas where conventional internet connectivity might not be available. The GSM module facilitates the communication of processed data to the mobile application, allowing users to monitor the real-time status and historical performance of street lights.

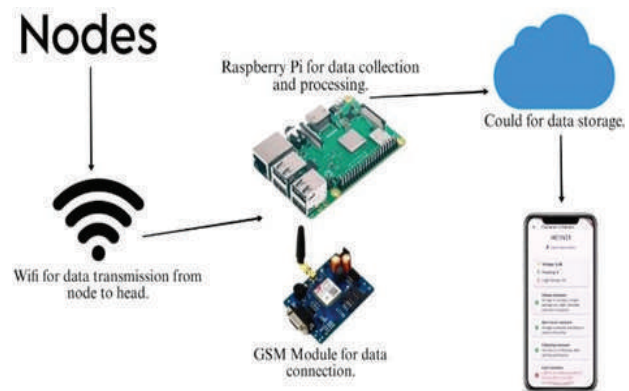


Fig. 3 Header Architecture

Nodes

The distributed nodes, installed on individual streetlight poles, are based on ESP8266 microcontrollers, known for low cost, power efficiency, and Wi-Fi connectivity. Each node collects real-time operational data using two key sensors: a voltage sensor, which detects electrical faults such as line breakages, surges, or drops, and an LDR sensor, which identifies dim lighting or complete failures despite stable power. Nodes process data locally and transmit it wirelessly to the central header via Wi-Fi, ensuring scalability and resilience as each operates independently. Powered by the streetlight supply or a regulated DC source, these nodes seamlessly integrate with existing infrastructure, simplifying installation and maintenance.

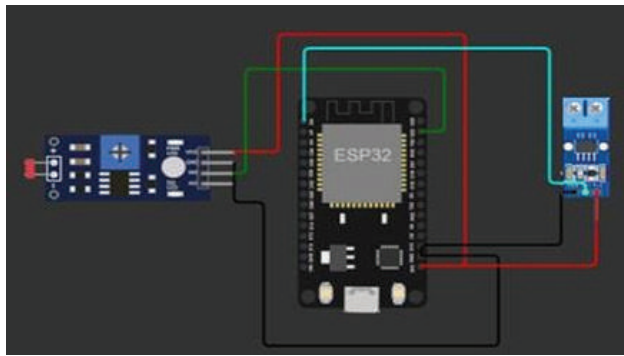


Fig. 4 Node Circuit Diagram

Flowchart

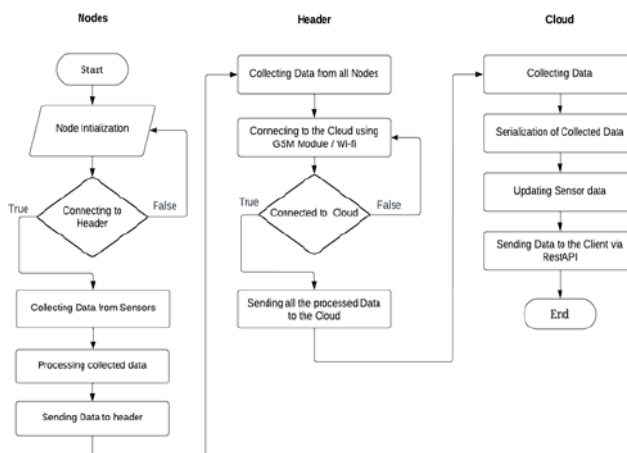


Fig. 5 Flowchart of working

The Street Light Fault Detection System follows a structured process: sensor-equipped nodes continuously monitor voltage and luminance, detecting faults based on predefined thresholds. Detected faults are transmitted via Wi-Fi to a Raspberry Pi header, which aggregates and processes the data locally. The system then classifies faults (e.g., broken lights, flickering, voltage drops) and transmits the processed data to the cloud via GSM for storage and analysis. Finally, the mobile application provides real-time alerts, displaying fault details, pole identification, and location for swift maintenance responses.

RESULTS AND DISCUSSION

The system design focuses on structuring the components and their interactions to achieve efficient fault detection and monitoring of streetlights. It lays the foundation for a robust IoT-based network connecting sensors, microcontrollers, and communication modules to a central header. The system ensures seamless data flow between

nodes and the mobile application, facilitating real-time monitoring and fault detection. The Prototype of the Proposed model is depicted below :-

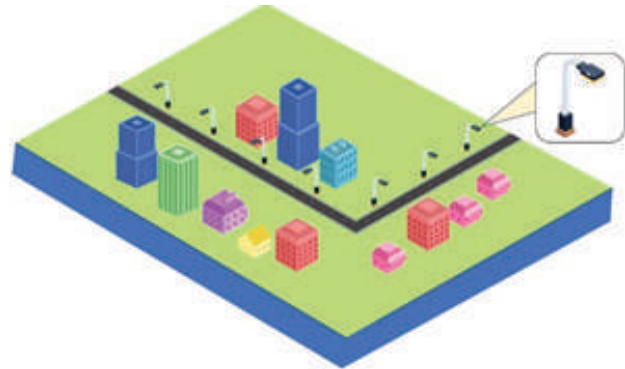


Fig. 6 Prototype Model Design

The implementation phase develops a fully functional IoT- based fault detection system by integrating ESP8266 nodes, STM microcontrollers, voltage sensors, and LDRs. These nodes collect and transmit voltage and luminance data to a Raspberry Pi Zero W header, which processes and forwards it to the cloud via GSM. The Django REST Framework enables seamless backend communication, while a Flutter- based mobile app provides real-time streetlight monitoring. Thorough hardware and software testing ensures reliability and scalability.

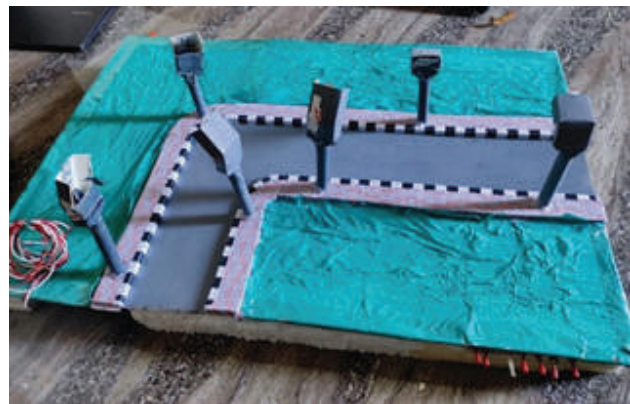


Fig. 7 Prototype Model Implementation

Mobile Application Dashboard

The mobile application provides a real-time, color-coded status of each streetlight node for easy monitoring. Each node is uniquely identified and displayed with green (normal operation), yellow (warning), or red (critical fault) indicators. Users can access detailed insights, including wire connection status, voltage levels, light operation, and

flickering detection. Fault alerts are received within 2-3 seconds, ensuring real-time response. The app also features data visualization tools, displaying voltage and luminance trends to help users identify anomalies efficiently. This intuitive interface enables quick assessment and prioritization of maintenance actions, enhancing streetlight management and operational efficiency.

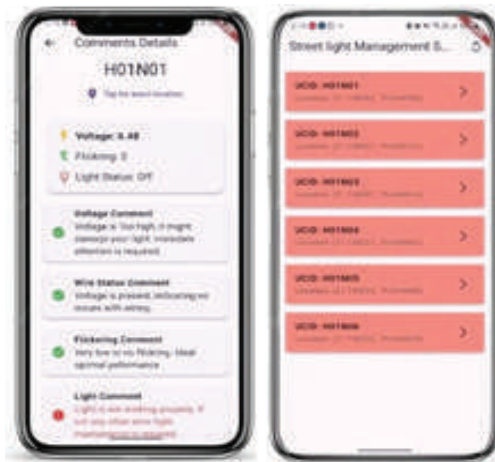


Fig. 8 App Output

System Performance Metrics Table

Table 1 System Performance

Nodes	Node 1	Node 2	Node 3	Node 4
Parameters				
Flickering (LDR)	1	4	0	1
Voltage	6.48v	3.24v	0.2v	6.33v
Wire-Status	Connected	Current Leakage	Possible Breakage	Connected
Light	On	On	Off	On
Status	Optimal Working	Minor issues	Critical Fault	Optimal Working

Data Analysis

The data analysis phase also highlighted key challenges, such as occasional delays in data transmission and variations in luminance readings under different weather conditions. These findings helped refine the system's

calibration and improve overall accuracy. Ultimately, the analysis proved that the system successfully meets its objectives of real-time fault detection and efficient monitoring of streetlights.

The System Performance Metrics Table provides insights into fault detection accuracy and streetlight monitoring. The analysis integrates data from the LDR sensor (flickering and light status) and the voltage sensor (voltage readings), enabling precise identification of faults. Based on the table, Node 3 exhibited a critical fault, reporting 0.2V and an off light status, indicating a possible line breakage. Node 2 showed minor issues due to current leakage and high flickering (4 LDR readings), suggesting voltage instability (3.24V). Nodes 1 and 4 functioned optimally, with stable voltage readings and light operation.

The color-coded status indicators confirmed real-time classification of faults, allowing immediate detection of light failure, voltage fluctuations, and wiring issues. While the system achieved high accuracy, challenges such as delays in data transmission and luminance variations due to weather conditions were observed, leading to calibration refinements. Overall, the analysis demonstrated the system's efficiency in real-time fault detection and monitoring, ensuring enhanced reliability and performance in urban streetlight management.

CONCLUSIONS

The proposed Street Light Fault Detection and Prevention System successfully integrates IoT technology to modernize urban infrastructure. Using a mesh network of sensor-equipped nodes communicating wirelessly with a centralized header, the system enables real-time monitoring of streetlights. Each ESP8266-based node detects voltage irregularities, luminance issues, and flickering, transmitting data to a Raspberry Pi Zero W header, which relays it to a mobile application via GSM. This enhances fault detection efficiency, reduces manual inspections, and lowers maintenance costs.

The system accurately identifies faults such as light outages, line breakages, and voltage surges, ensuring targeted maintenance and minimizing energy waste. A user-friendly mobile app with color-coded indicators provides instant status updates, improving response time and operational reliability. With its scalable, cost-effective, and automated design, this system supports smart city initiatives, promoting sustainability, energy efficiency, and enhanced public safety.

ACKNOWLEDGEMENT

We sincerely express our gratitude to our mentors and faculty members for their invaluable guidance and support throughout this research. We also extend our appreciation to our peers for their constructive feedback and discussions that enhanced the development of this project. Lastly, we acknowledge the resources and facilities that enabled the successful implementation of our Street Light Fault Detection System, contributing to advancements in smart city infrastructure.

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Manufacturing Lead Time Reduction using Value Stream Mapping (VSM)

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ABSTRACT

This research explores the enhancement of productivity within an aluminum utensil manufacturing environment through the strategic application of lean principles, particularly Value Stream Mapping (VSM). The study evaluates existing processes, identifying bottlenecks and inefficiencies contributing to prolonged lead times. By streamlining workflows and reducing non-value-added activities, the implementation of VSM demonstrates significant lead time reduction, enhancing both productivity and profitability. The findings reveal a 9.25% increase in profitability, emphasizing the financial and operational impact of adopting lean methodologies.

KEYWORDS : *CART, Classification, Artificial intelligence, Random forest.*

INTRODUCTION

Manufacturing lead time is a critical metric that directly impacts a company's operational efficiency, cost structure, and customer satisfaction. Lead time encompasses the total duration from the procurement of raw materials to the delivery of finished products, including pre-processing, setup, processing, waiting, inspection, and transportation stages. In today's competitive market, reducing lead time is essential for manufacturers to enhance productivity, minimize waste, and meet customer demands promptly.

Lean manufacturing optimizes production by eliminating waste and improving efficiency. It originated from the Toyota Production System and emphasizes continuous improvement through tools like VSM, Just-In-Time (JIT), Kanban, 5S, and Kaizen. Each tool targets specific inefficiencies, aiming to enhance value-added processes. Among these, VSM stands out as a powerful visual tool that maps the current state of a process, identifies bottlenecks, and designs an optimized future state. [5, 8, 10]

This study focuses on applying VSM to reduce manufacturing lead time in an aluminum utensil production company, "Balaji Trading Company."

By analyzing the existing processes, identifying inefficiencies, and implementing targeted improvements, the research aims to enhance operational efficiency and profitability.

2.0 LITERATURE REVIEW

Bottlenecks in manufacturing and logistics processes significantly affect productivity and operational efficiency. Several studies have explored various methodologies, including Lean Manufacturing, Six Sigma, and Value Stream Mapping (VSM), to identify and address these bottlenecks. This section reviews key research papers, focusing on the strategies and tools applied and their impacts on improving industrial performance. Nandakumara et al. (2018) implemented Lean Six Sigma using the DMAIC (Define, Measure, Analyze, Improve, Control) framework to enhance production and packaging processes in a food processing company. By identifying and eliminating

bottlenecks, the study successfully reduced defect rates and improved overall efficiency [1]. Similarly, Haque et al. (2018) applied line balancing techniques in a garment manufacturing setting. By reorganizing the sewing line, they achieved a significant boost in efficiency, increasing productivity from 47% to 57 pieces per hour [3].

Simulation models provide a dynamic way to detect and address bottlenecks. Krishnan et al. (2017) used simulation analysis to identify the fabric calendaring process as the primary bottleneck in a tire manufacturing plant [2].

In battery manufacturing, Silva et al. (2021) pinpointed critical bottlenecks in the cutting and annealing processes. Their study highlighted the role of simulation in improving energy efficiency and process flow [4]. Additionally, Pekarcikova et al. (2021) demonstrated the effectiveness of Tecnomatix Plant Simulation software in optimizing logistics flows, showing that simulation can dynamically detect inefficiencies and improve production and transportation systems [6, 16].

Value Stream Mapping (VSM) is widely recognized for identifying inefficiencies and streamlining processes. Umredkar and Solke (2015) identified the Cone Assembly machine as a bottleneck in taper roller bearing production and recommended strategies to enhance flow and throughput [5]. In the automotive industry, Suryawanshi et al. (2017) applied VSM to eliminate non-value-added activities, significantly improving process efficiency [10]. Similarly, Kumar and Kumar (2016) demonstrated that VSM effectively identifies waste and optimizes operations within Indian manufacturing environments [12]. Lean principles have been successfully applied in various sectors. Fernandes Junior and Pinto (2020) utilized lean techniques to enhance productivity in a swine slaughterhouse. They balanced operator stations and improved line efficiency through simulation [7]. In the silk production industry, Sujatha and Rao (2013) explored the implementation of lean tools such as inventory management and material handling, noting their positive impact on operational performance [19].

In a mattress manufacturing line, Gundogar et al. (2016) applied the Theory of Constraints (TOC) to identify and eliminate bottlenecks. By balancing the flow of semi-finished materials, they increased overall production output [14]. Similarly, Dirnberger and Barkan (2007) introduced “lean railroading” to enhance the performance of railroad classification terminals, improving service reliability and network efficiency [20]. Lean methodologies extend

beyond traditional manufacturing environments. Zhao et al. (2014) applied bottleneck detection techniques to improve patient flow in hospital emergency departments. Their approach identified key areas of congestion and streamlined operations [17]. In the education sector, Cespedes-Mota et al. (2021) adapted lean concepts to address challenges such as outdated curricula and resource limitations in engineering education, promoting systemic improvements [18].

METHODOLOGY

The methodology employed in this study involves a structured approach using Value Stream Mapping (VSM) to analyze and optimize the aluminum utensil manufacturing process. The key steps include:

Data Collection and Current State

Mapping

- **Data Collection:** Comprehensive data was gathered on various stages of the manufacturing process, including cycle times, changeover times, material flow, and operator efficiency. Observations were made on-site to capture real-time data and identify sources of waste.



Fig. 1 Flow of production process

- **Current Value Stream Mapping (CVSM):** A CVSM was created to provide a visual representation of the existing process flow. This map included key metrics such as cycle time, changeover time, and the number of operators at each stage. It highlighted areas with significant delays, bottlenecks, and non-value-added activities.

Bottleneck Identification and Root Cause

Analysis

- **Fishbone Diagram (Ishikawa):** This tool was used to identify potential causes of inefficiencies, categorized under manpower, machinery, methods, materials, measurement, and environment.

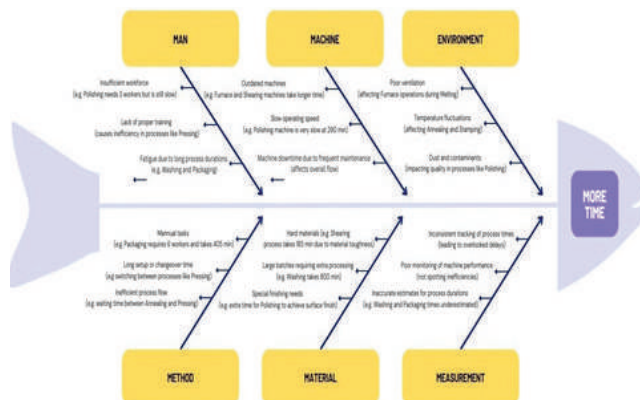


Fig. 2 Fish-Bone Diagram

- **Pareto Analysis:** This statistical method helped prioritize the most critical issues affecting lead time, focusing on the “vital few” problems that contributed to the majority of delays.

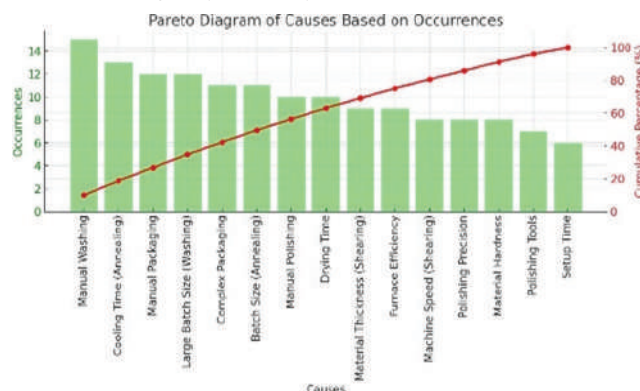


Fig. 3 Pareto Analysis

Development of Future State Mapping

- **Future Value Stream Mapping (FVSM):** Based on the insights from CVSM and root cause analysis, an improved FVSM was designed. This future state map proposed solutions to eliminate identified bottlenecks, streamline material flow, and optimize resource allocation. Key improvements included reducing setup times, enhancing material handling practices, and implementing lean tools like Kanban and 5S.

Implementation and Continuous

Monitoring

- The proposed solutions were implemented in phases, with continuous monitoring to assess their impact on lead time and overall efficiency. Key performance indicators (KPIs) such as cycle time, lead time, and defect rates were tracked to evaluate the effectiveness of the interventions.

RESULTS AND DISCUSSION

Current State Analysis

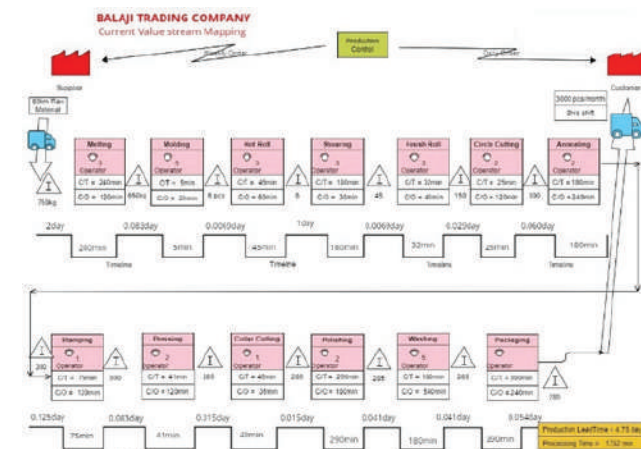


Fig. 4 Current Value Stream Mapping

The CVSM revealed several inefficiencies within the aluminum utensil manufacturing process. Key findings included:

- **Excessive Lead Time:** The total production lead time was 4.75 days, with significant delays in processes such as annealing, pressing, and polishing.
- **Resource Underutilization:** Some processes had more operators than necessary, leading to inefficient labor utilization.
- **Material Handling Issues:** Inefficient material flow and handling practices contributed to longer queue times and increased the risk of defects.

Future State Improvements

The implementation of FVSM resulted in several significant improvements:

- **Reduced Lead Time:** The lead time was reduced from 4.75 days to 4.31 days, reflecting a 9.25% improvement in overall efficiency.

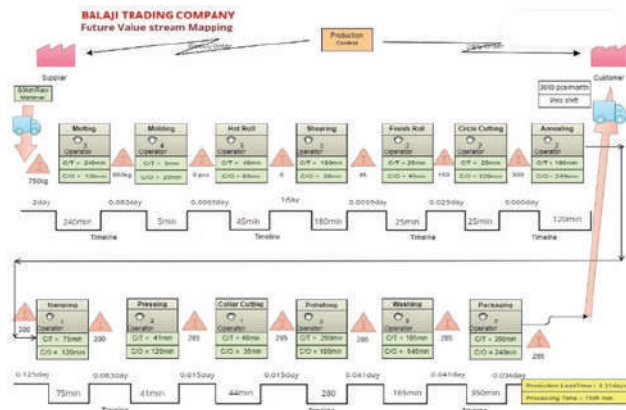


Fig. 5 Future Value Stream Mapping

- **Increased Productivity:** Monthly production increased from 1,500 units to 1,653 units. This increase in output was achieved without significant additional investments, demonstrating the impact of process optimization.
- **Enhanced Profitability:** The monthly profit increased from ₹3,37,500 to ₹3,71,925, resulting in an annual profit increase of ₹4,63,100. After accounting for implementation costs, the net profit improvement was ₹3, 95,100.

Operational Improvements

- **Labor Optimization:** The number of operators required for certain processes, such as collar cutting and polishing, was reduced, leading to better workforce utilization.
- **Material Flow:** Implementing Kanban and reorganizing the workspace using 5S principles streamlined material flow, reducing unnecessary movement and waiting times.
- **Quality Enhancement:** Improved process control and reduced setup times minimized defects, enhancing the overall quality of the finished products.

Comparative Analysis

Metric	Current VSM	Future VSM	Improvement (%)
Lead Time (Days)	4.75	4.31	9.25%
Monthly Production (Units)	1500	1653	10.2%
Annual Profit (₹)	40,50,000	44,63,100	9.25%

The comparative analysis highlights the tangible benefits of implementing VSM. The reduction in lead time and increased output demonstrate the effectiveness of lean methodologies in enhancing operational efficiency and profitability.

CONCLUSIONS

The implementation of VSM in aluminum utensil manufacturing significantly reduced lead time and improved profitability. This case study demonstrates the strategic value of lean tools in enhancing operational efficiency, customer satisfaction, and financial performance. Future research could explore integrating advanced simulations and digital twin technologies to further optimize manufacturing processes.

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Development of an IoT-Based System for Real-Time Vibration Monitoring and Predictive Maintenance

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ABSTRACT

This paper presents the development of an IoT-based vibration analysis system to improve real-time monitoring and predictive maintenance in mechanical engineering applications. Traditional vibration analysis methods rely on periodic inspections, which can delay fault detection and increase downtime. The proposed system addresses these limitations by integrating a MEMS accelerometer (ADXL345) with a NodeMCU microcontroller to measure vibrations along three axes (X, Y, Z). Vibration data is transmitted to the ThingSpeak cloud for real-time visualization and analysis, while MATLAB is used for plotting vibration patterns. Predefined thresholds trigger alerts through a buzzer and automated email notifications, ensuring immediate action when abnormal vibration levels are detected. The hardware design includes a compact 3D-printed enclosure for industrial compatibility. This system provides continuous monitoring, automated data logging, and advanced fault detection mechanisms, making it ideal for industries like manufacturing, aerospace, automotive, and energy. The results demonstrate the system's capability to enhance maintenance efficiency, reduce downtime, and extend equipment lifespan. Future enhancements could include integrating machine learning for predictive analytics and improving connectivity for remote applications. This research establishes a robust framework for scalable IoT solutions in vibration monitoring, contributing to the advancement of predictive maintenance practices.

KEYWORDS : *IoT-based vibration analysis, Predictive maintenance, MEMS accelerometer, Real-time monitoring, Industrial fault detection.*

INTRODUCTION

The emergence of the Internet of Things (IoT) has revolutionized the way data is collected, processed, and analyzed across various domains. One such critical application is vibration analysis, which plays a pivotal role in predictive maintenance, structural health monitoring, and machinery diagnostics. The integration of IoT with vibration analysis not only enhances real-time monitoring capabilities but also enables automation, cost reduction, and improved operational efficiency. This paper delves into the development of an IoT-based vibration analysis system, elucidating its importance, methodology, and

impact on modern industries. Vibration analysis is a cornerstone in the domain of predictive maintenance and diagnostics. Excessive vibration in machinery can lead to catastrophic failures, increased downtime, and costly repairs. Traditional vibration monitoring techniques rely heavily on manual interventions and static equipment, which often fall short of providing real-time insights [1]. IoT addresses these challenges by enabling continuous monitoring and predictive analytics [2].

IoT leverages interconnected sensors, devices, and platforms to collect and transmit data over the internet. This connectivity enables remote monitoring, real-

time data visualization, and automated fault diagnosis. Recent studies suggest that IoT-based systems can reduce maintenance costs by up to 30% and unplanned downtime by 50% [3]. This adaptability makes IoT particularly well-suited for vibration analysis. An IoT-based vibration analysis system typically comprises three main components: sensors, communication networks, and analytics platforms. Sensors such as accelerometers and gyroscopes capture vibration data with high precision. These sensors are embedded in critical machinery and transmit data to cloud platforms via communication protocols like MQTT, Wi-Fi, or LoRaWAN [4]. The data is then analyzed using advanced algorithms and machine learning models to identify patterns, anomalies, and potential faults [5].

The implementation of IoT in vibration analysis provides several advantages. Firstly, it ensures real-time monitoring, which is crucial for early fault detection [6]. Secondly, IoT systems offer scalability, allowing enterprises to monitor multiple assets across geographically dispersed locations. Thirdly, the integration of cloud computing enhances storage and computational capabilities, enabling complex data analytics and visualization [7]. Despite the numerous benefits, the development of IoT-based vibration analysis systems is not without challenges. Data security and privacy remain primary concerns, as sensitive information is transmitted over the internet [8]. Additionally, the deployment of IoT devices in harsh industrial environments poses durability and reliability issues [9]. The design and implementation of efficient algorithms for real-time data processing also demand significant computational resources and expertise [10].

The adoption of IoT-based vibration analysis systems spans various industries, including manufacturing, energy, transportation, and construction. In manufacturing, these systems are employed for monitoring critical machinery such as turbines, pumps, and compressors [11]. In the energy sector, IoT systems are used for monitoring wind turbines and solar panels, enhancing energy efficiency and reducing operational risks [12]. The transportation industry leverages IoT for monitoring rail tracks and vehicle components, ensuring safety and reliability [13]. In construction, these systems play a vital role in assessing the structural integrity of buildings and bridges [14]. The future of IoT-based vibration analysis systems lies in the integration of artificial intelligence (AI) and edge computing. AI-powered algorithms can predict failures with higher accuracy, enabling proactive maintenance

strategies [15]. Edge computing reduces latency by processing data closer to the source, making real-time decision-making more efficient [16]. Furthermore, advancements in sensor technology and wireless communication are expected to enhance the reliability and affordability of IoT systems [17].

The project titled “Development of IoT-Based Vibration Analysis System” aims to design and implement a real-time vibration monitoring system utilizing IoT technology. Vibration analysis plays a critical role in mechanical engineering, particularly in predictive maintenance of machinery. It involves detecting irregular vibration patterns that may indicate underlying mechanical issues such as unbalance, misalignment, bearing defects, or structural damage [18]. The proposed system addresses the limitations of traditional vibration analysis methods by providing continuous monitoring, automated data logging, and instant alerts when vibration thresholds are exceeded [19]. The system architecture features a MEMS accelerometer (ADXL345) integrated with a NodeMCU microcontroller to measure three-axis vibrations (X, Y, and Z). The data is transmitted to the ThingSpeak cloud for real-time visualization and analysis, with MATLAB used to plot separate charts for each axis [20]. Thresholds are set based on research, triggering alerts if exceeded. When a vibration level surpasses these limits, a buzzer sounds for 4 seconds, and email alerts are automatically sent via ThingSpeak’s API for prompt notification [21]. The hardware design includes a breadboard for connections and a 3D-printed enclosure to protect the system, with space for the NodeMCU, accelerometer, and cables.

This IoT-based solution offers continuous monitoring and immediate alerts, enhancing maintenance by enabling early fault detection and reducing downtime and costs. This project demonstrates IoT’s potential in vibration monitoring and opens avenues for future improvements, such as machine learning for predictive analysis [22]. The solution is well-suited for industries where machinery uptime is critical, providing a valuable tool for predictive maintenance in sectors like manufacturing, automotive, aerospace, and energy [23]. This paper contributes to the field of mechanical engineering by advancing IoT-driven maintenance practices and proposes future directions for enhanced system capabilities [24, 25].

METHODOLOGY

The development of the IoT-based vibration analysis system was organized into multiple phases, encompassing

system design, hardware setup, software development, data acquisition, and testing. The system was designed to monitor machinery vibrations using a MEMS accelerometer (ADXL345) integrated with an ESP8266 NodeMCU microcontroller. The accelerometer captured vibrations along three axes (X, Y, and Z) and measured acceleration in terms of g-values. This data was processed by the NodeMCU and transmitted via Wi-Fi to the ThingSpeak cloud for real-time monitoring. A buzzer was included in the setup to provide immediate alerts when vibration levels exceeded predefined thresholds. The circuit diagram detailing these connections is illustrated in Fig.1.

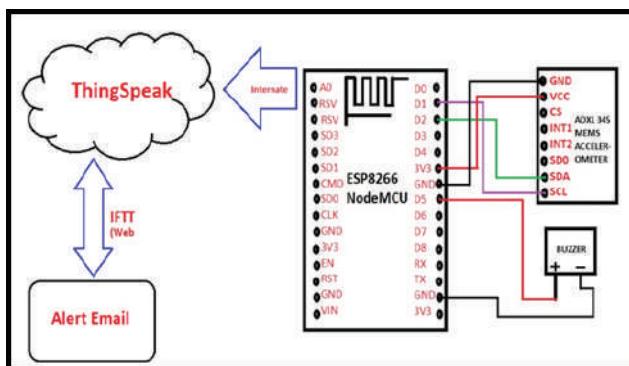


Fig. 1 Circuit Diagram illustrating the connections between the accelerometer, NodeMCU, buzzer, and power source

The hardware setup comprised the ADXL345 MEMS accelerometer for accurate vibration measurements and the ESP8266 NodeMCU for data acquisition and transmission. A breadboard facilitated temporary connections during the prototyping phase, while connecting wires linked the components. A 3D-printed enclosure was developed to house the system, ensuring its durability and compatibility with industrial environments. The buzzer was integrated as an audible alert mechanism, further enhancing the system's effectiveness in real-time fault detection.

The software was developed using the Arduino IDE, with code structured to initialize Wi-Fi connections, acquire vibration data from the accelerometer, and upload it to the ThingSpeak cloud for analysis and visualization. Data was processed in real-time to enable continuous monitoring. The system was programmed to trigger alerts via the buzzer and email notifications when abnormal vibration levels were detected. This integration ensures prompt responses to potential mechanical issues, reducing downtime and maintenance costs.

Testing and validation were conducted to ensure the system's reliability. Thresholds for vibration levels were set, and the system's performance was evaluated under various conditions. The hardware and software components were rigorously tested for functionality, accuracy, and responsiveness. The system demonstrated its ability to continuously monitor vibrations and provide timely alerts, showcasing its potential as a reliable tool for predictive maintenance in industrial applications.

RESULTS AND DISCUSSION

The IoT-based vibration analysis system was successfully developed and tested for real-time vibration monitoring and alert generation. The system effectively captured acceleration data along the X, Y, and Z axes using the ADXL345 MEMS accelerometer, processed it via the ESP8266 NodeMCU microcontroller, and transmitted it to the ThingSpeak cloud for visualization and analysis. The outcomes demonstrated the system's reliability in detecting abnormal vibration levels and issuing alerts promptly.

Results



Fig. 2 Validation of email alert system during threshold testing

Testing involved measuring vibrations in four stages: the initial stage with the grinder off, the grinder turned on, the grinder turned off, and intermediate states during start and stop. At the initial stage, acceleration values were consistent across axes, with minor deviations based on the sensor's orientation. Upon starting and stopping the grinder, vibration levels spiked significantly across all

axes due to the sudden change in motion. The thresholds for alerts were established as follows: 2 m/s² for the X and Y axes and 12 m/s² for the Z-axis. These values ensured that alerts were generated only during significant vibration events.

During testing, when vibration values exceeded these thresholds, the system generated an audible buzzer alert and sent email notifications to predefined recipients. Validation of the email alerts is shown in Fig.2 demonstrating the functionality of the notification system under real-time operating conditions.

Discussion

The results illustrate the capability of IoT-based systems in providing continuous monitoring and predictive maintenance. The integration of ThingSpeak for data visualization and automated alerts ensures timely intervention in industrial applications (Fig.3 and Fig.4). However, certain challenges were noted, including dependency on Wi-Fi connectivity, which may limit the system's functionality in remote areas, and potential inaccuracies in sensor readings due to environmental interference.



Fig. 3 Visualization of vibration data (X, Y, Z axes) on ThingSpeak

To address these challenges, future improvements can include incorporating advanced analytics like machine learning for enhanced fault prediction and utilizing alternative communication technologies such as LoRaWAN for extended connectivity. Despite these limitations, the current system demonstrated its effectiveness in reducing downtime and maintenance costs, showcasing its value in industries requiring high uptime reliability.

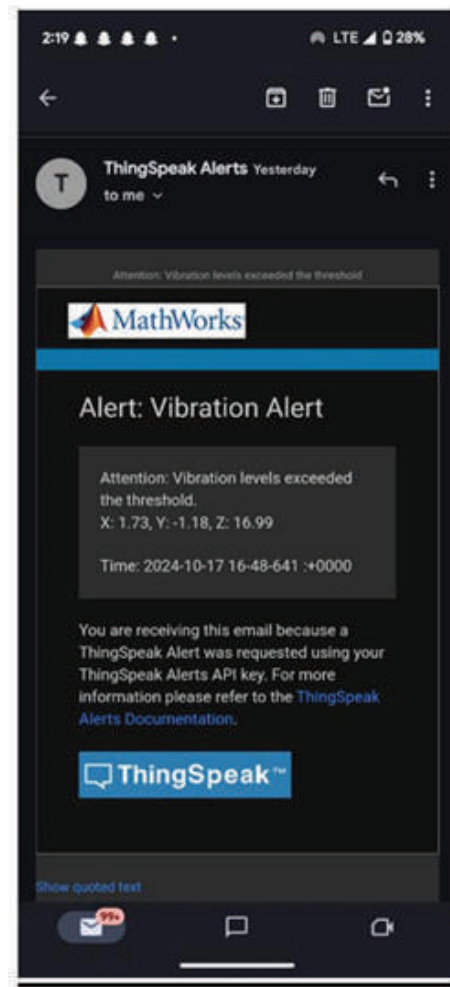


Fig. 4 Automated email alert example with vibration details and timestamp

Fig. 5 illustrates the real-time vibration data captured along the X, Y, and Z axes during the system's operation. The accelerometer (ADXL345) records acceleration values for each axis, which are transmitted to the ThingSpeak cloud platform via the NodeMCU microcontroller. The graph provides a visual representation of the vibration levels over time, allowing maintenance personnel to observe patterns and anomalies. In the figure, the X and Y axes generally show lower amplitude vibrations compared to the Z-axis, which typically records higher values due to its alignment with the primary axis of the vibration source. Significant spikes in the data correspond to events like the activation or deactivation of machinery, as detailed in the results section. This visualization is integral to the system's functionality, enabling quick identification of abnormal conditions that may require intervention.

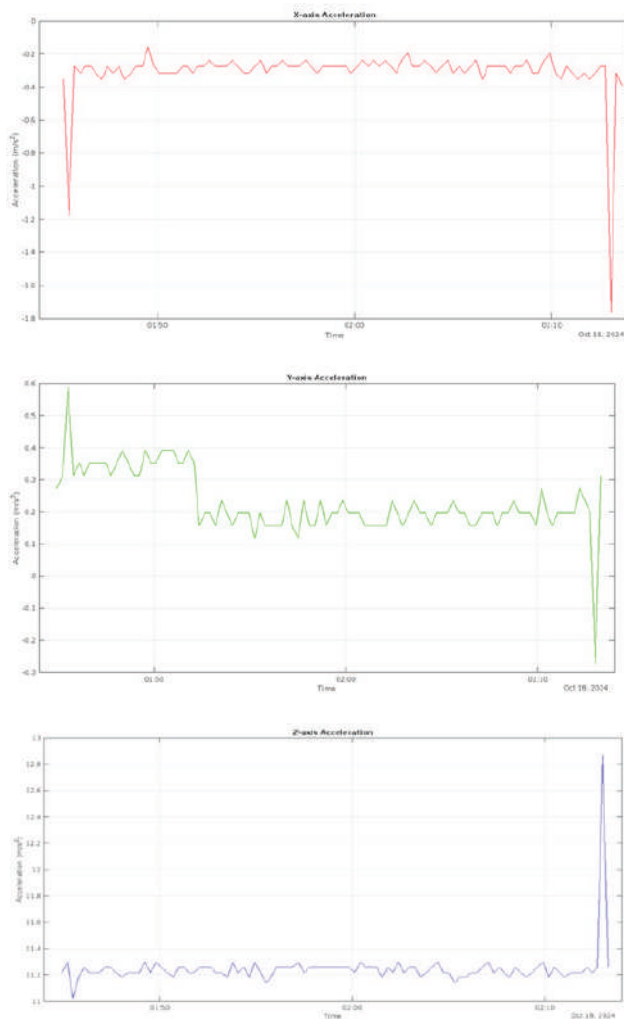


Fig. 5 Real-time vibration data visualization along the X, Y, Z axes

CONCLUSIONS

The development of the IoT-based vibration analysis system successfully demonstrated its capability as an efficient tool for real-time monitoring and predictive maintenance. By integrating the ADXL345 MEMS accelerometer, ESP8266 NodeMCU, and ThingSpeak cloud platform, the system provided accurate vibration measurements, real-time visualization, and automated alert mechanisms. This innovative solution addressed the limitations of traditional vibration analysis methods by offering continuous monitoring, reducing downtime, and enabling proactive fault detection.

The system was rigorously tested across multiple scenarios, confirming its reliability in identifying

abnormal vibrations and promptly notifying maintenance personnel through audible alerts and email notifications. The compact hardware design and the cloud-based data visualization framework make it suitable for various industrial applications, including manufacturing, automotive, aerospace, and energy sectors. While the system proved effective, challenges such as Wi-Fi dependency and environmental influences on sensor accuracy were identified. These limitations can be mitigated through future enhancements, such as incorporating machine learning algorithms for advanced fault prediction, expanding connectivity options for remote deployments, and integrating additional sensors for comprehensive condition monitoring. In conclusion, this IoT-based vibration analysis system provides a scalable, cost-effective solution for predictive maintenance. It paves the way for further advancements in condition monitoring technologies, offering significant potential to enhance operational efficiency, reduce maintenance costs, and increase the lifespan of industrial machinery.

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Smart City Transport: Passenger- Centric Intelligent Scheduling System for Urban Public Transit

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ABSTRACT

This paper presents an intelligent system designed to optimize public transportation schedules by leveraging machine learning algorithms and real-time data on passenger demand and traffic conditions. Traditional fixed schedules in public transportation often led to inefficiencies due to dynamic changes in passenger numbers and unpredictable traffic patterns. Our proposed solution integrates sensors at bus stops and on vehicles, which collect data that is analyzed by machine learning models. This allows for dynamic schedule adjustments, reducing wait times and improving resource utilization. In addition, interactive displays at bus stops provide passengers with real-time information on bus arrivals, routes, and occupancy. By optimizing bus routes and schedules, the system also contributes to environmental sustainability by reducing fuel consumption and emissions. The results show that the implementation of this smart scheduling system leads to significant improvements in operational efficiency and passenger satisfaction. This project aims to establish a model for future smart city transportation systems that adapt to real-time conditions, benefiting both commuters and the environment.

KEYWORDS : *Public transportation, Machine learning, Real-time data, Passenger demand, Traffic conditions, Smart bus stops, Sensors, Environmental sustainability.*

INTRODUCTION

Background

Traditionally, public transportation operates based on a schedule, and very often this is not quite dynamic enough for urban passengers because passenger demand changes and decreases with time while traffic happens occasionally in unforeseen ways. With urban growth, such inefficiencies only add up to increased Traditionally, public transportation operates based on a schedule, and very often this is not quite dynamic waiting times, overcrowding, and higher costs of operating. Such advanced technologies as real-time data collection and machine learning enable the possibility of reformulating the way public transport may respond to urban challenges. By harnessing

such technologies, this project envisions a responsive scheduling system which may be designed to better serve the real-time needs in more efficient, sustainable, and passenger-friendly ways for public transportation.

Motivation

The main drive behind the project is the acute need for efficient and sustainable urban mobility solutions. Taking into account the fast-growing population within cities and the increasing burden of traffic congestion, such public transportation systems face quite a challenge in meeting the demands of their commuters. Schedules in fixed time-slots lead to overcrowding in buses, extended periods of waiting, and other inefficient use of resources. This project will use machine learning and real-time data to change

public transportation scheduling, optimize routes, and schedules under the actual conditions. This innovation is aimed at improving the experience of passengers while minimizing the negative impact on the environment and promoting a smarter and more adaptable approach to urban transit.

RELATED WORK

IoT in Smart Transportation Systems

Many research works have been conducted to know how IoT can help to make public transport efficient. Islam et al. identified the role of smart sensors in IoT- based solutions as providing real-time data acquisition at bus stops that may contribute to responsive transport systems [4]. Similar to this, Kamal et al. (2019) discussed IoT-enabled smart bus stops and discussed their potential to offer real-time information and improve the commuter experience in urban regions [3]. Such studies show that IoT devices are increasingly being used in public transport but there are integration challenges [8].

Smart Bus Stop Design for Inclusivity and Efficiency

There is also strong research into smart bus stop designs that are both inclusive and environmentally efficient. For instance, Rosa et al. (2023) introduced a sustainable bus stop which was powered by renewable energy sources, accessible, and informative to the public regardless of age [5]. Another proposal made by Padrón et al. (2020) involved smart bus stops designed for elderly passengers to ensure that passengers receive easy-to-read information displays and a reduction in waiting time [2]. These designs emphasize ease of use interfaces and energy efficiency, though they do involve heavy investments in infrastructure for large-scale deployment.

Optimization Techniques in Public Transportation Scheduling

Application of optimization techniques to transportation scheduling has been an emerging concern in the studies recently carried out. Xiao et al. (2024) identified some multi-objective optimization methods for route planning, in an effort to optimize costs while minimizing environmental effects [7]. Lu et al. (2018) proposed an interdisciplinary method that coupled optimization with real-time information to optimize the route performance [9]. However, the complexity remains because optimizing the models would be an even greater challenge than the fact that urban traffic is not stable.

Web Enhancing Social Inclusiveness in Urban Mobility

In recent years, research in the public transport domain has been increasing focus on social inclusiveness. Porru et al. (2020) have discussed issues and opportunities regarding smart mobility integration in both rural and urban settings in an attempt to bridge the accessibility gaps across various communities [1]. Arora (2014) discusses the smart bus stop design for metropolitan cities, specifically Tier-1 cities in India, focusing on social inclusiveness as well as fulfilling diverse user requirements [6]. These studies underscore the need for inclusive design, but at the same time also highlight that it is not easy to include the needs of diverse demographics.

A New Approach of Automobile Localization System Using GPS and GSM/GPRS Transmission

The work published in 2006 by Ioan Lita, Ion Bogdan Cioc, and Daniel Alexandru Visan is the one providing an affordable automotive localization system, using GPS and GSM-SMS technologies for the vehicle's tracking and communication. The system gives real-time updates to the owner of the vehicle by sending SMS messages concerning important events such as the activation of the car alarm or the crossing of speed limits set. The system prevents car theft, supervises young drivers, and gives a navigator through location tracking. A GPS-GSM based information and control system offers security and peace to any owner of a vehicle.

METHODOLOGY

Data gathering and processing

The dataset consists of real-time and historical data related to passenger counts, traffic conditions, and schedule timings for several months. The data set contains passenger entry and exit records from infrared and ultrasonic sensors, vehicle speeds, traffic density, and other relevant environmental metrics.

Mechanical Design and Implementation

The Mechanical Aspect of the Project: Optimal passenger flow, shelter, and seating will be optimized in the model bus stop. Sensors and interactive displays may be included in the design by creating a layout drawn up with CATIA or Creo software, wherein it is possible to have a live feed-up. There should be infrared and ultrasonic passenger counting sensors positioned at entry-exit points so as to accurately determine the number of passengers. More, some environmental sensors are also designed to monitor

outside conditions likely to influence the passenger behaviors or comfort in waiting for transportation at the bus stop.

Machine Learning Model and Optimization

The feeds to the machine learning model would be used for predicting demands and optimizing schedules through regression algorithms that estimate peak hours of usage and accordingly, adjust the bus schedule to those estimates. Furthermore, real-time traffic and passenger data enable dynamic adjustment within the model. Finally, reinforcement learning algorithms minimize waiting times and maximize the route efficiency of scheduling decisions made by the model. Since the model is continuously fed with new data, it can continue to hone in on its predictive accuracy based on variations in demand and changing conditions of traffic [5].

Testing, Calibration, and Integration

It is validated in sensor accuracy by simulating the movements of passengers and adjusting sensitivity to reduce false readings. It is connected with a microcontroller (for example, Raspberry Pi) to centralize data collection. Calibration is performed to operate it in various weather conditions reliably. A solar panel is used to power the microcontroller for sustainability and reduce reliance on other power sources.

SYSTEM ARCHITECTURE

The proposed system aims at revolutionizing the way public transportation scheduling is approached. Advanced machine learning algorithms and real-time data collection allow for dynamic adjustment in the public transportation schedule. Its primary aim is to deal with the inefficiencies that prevail in traditional fixed schedules and cannot account for changes in passenger demand as well as real-time traffic conditions. Our solution will apply a number of technologies and methodologies in design, construction, and operation to create a responsive and sustainable system that enhances efficiency, operational cost, and passenger satisfaction.

System Overview

A Sensors for Data Collection

At its core, are sensors located at bus stops and on buses. These sensors are generally collecting a variety of data from passengers counted, location, speed, and

environmental conditions. Two types of sensors will be used in this system:

- **Infrared (IR) Sensors:** These are mounted at the entrance and exit of bus-es. These sense the change in infrared light every time passengers board or alight.
- **Ultrasonic Sensors:** These sensors determine the time taken for a sound wave to return to the sensor after hitting an object in motion (a passenger entering or exiting), ensuring accurate counting of passengers.
- **GPS Sensors:** These are installed in buses to track the real-time location and bus routes.

Intelligent Bus Stops

There are information boards and solar panels attached to these bus stops to give real-time information of the arrival of buses along with route information to passengers as they collect data to be analyzed.

Data Transmission and Processing

Sensors transmit data to a central server wirelessly using Wi-Fi or cellular networks. The system does preliminary data processing before forwarding for more analysis using the machine learning models.

Machine Learning Algorithms

Machine learning is at the heart of the system. Regression models, time-series forecasting-for example, ARIMA, LSTM as well as neural networks predict the demand and adjust the schedules in real time.

Dynamic Scheduling and Route Optimization

The bus's schedule will be updated in real time to optimize routes with optimal fuel usage by incorporating optimization techniques like GA or genetic algorithms.

Passenger Interface

Smart bus stops fitted with interactive screens and mobile applications assist in providing the passengers real-time information about buses and routes in order to be benefitted by a better experience overall.

Sustainability Features

Solar-power bus stops, optimized routes, and reduced idle times reduce emissions, making for a more environmentally sustainable entity.

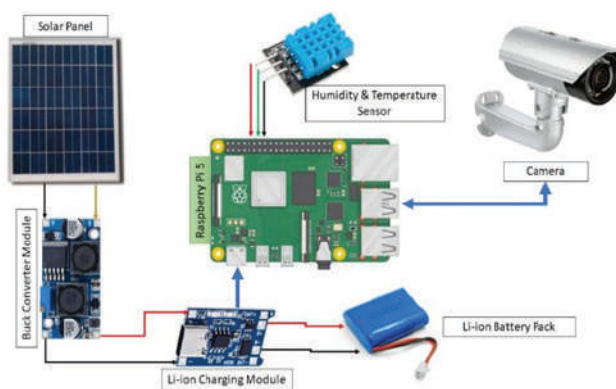


Fig. 1. Block diagram of Connection for Smart Bus Stop

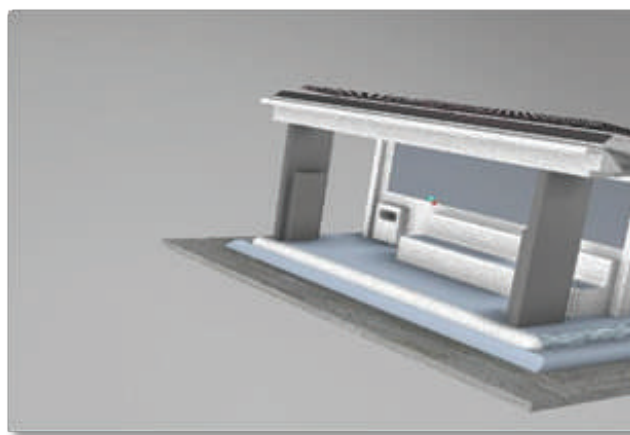


Fig 2. Representation of the Smart Bus Stop Model Design in Creo Software

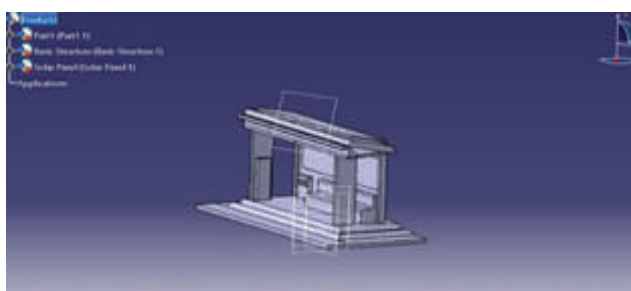


Fig 3. Representation of the Smart Bus Stop Model Design in CATIA Software

RESULT AND DISCUSSION

The results of the study showed significant improvement of both transportation efficiency and passenger satisfaction. The system reduced bus idle times, which it managed to do by making schedule changes according to real-time data. That would minimize waiting time for passengers and deploy buses in a better way during peak hours. Real-

time information was also presented through interactive displays, further improving the commute. The optimized scheduling reduced fuel consumption and emissions by minimizing empty runs and idling. Energy efficiency of the system further improved by harnessing solar power for bus stop sensors and displays. One of the significant issues that arose was inconsistent traffic conditions, which forced the system to change schedules too frequently. As continuous data input and improvements of the machine learning model ensued, the changes were optimized over time. In a general sense, the system operated well in improving efficiency in operations and resources used in public transportation.

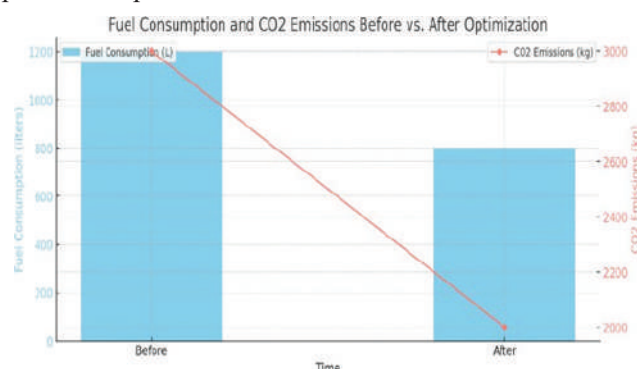


Fig 4. Fuel Consumption and CO₂ Emissions Before vs. After Optimization



Fig 5. Average Passenger Waiting Time Reduction

Limitation

The system was tested based on historical data where the performance was very promising. But with real-time stock data, there might arise issues of delayed updates to data or processing delay that might come along. Future improvement of the system should include aspects of processing in real time considering integration with live financial news and sentiment analysis for proper prediction. Historical prices and a few selected financial factors were

the base that formed the models. A combination of several advanced technical indicators or more macroeconomic variables might serve to further boost the predictions of the system.

Future Scope

Integration with Autonomous Vehicles

One of the exciting future directions for the proposed smart public transportation system is to integrate autonomous vehicles. With the underlying technology for self-driving buses being developed, it is easy to integrate that into the system described above and create an automated public transport network. An autonomous bus can make dynamic modifications to the route and schedules in real-time to accommodate the conditions of traffic as well as the demand for passengers, thus further optimizing the system. These vehicles can communicate with smart bus stops and other IoT-enabled infrastructure to allow for efficient fleet management without human intervention, leading to even greater efficiency, reduced operational costs, and enhanced safety.

Expansion to Multi-Modal Transportation Systems

This project's future scope is beyond bus scheduling. This will then allow the system to integrate many modes of public transportation, from trains to trams, and ride-sharing services. This can, therefore, form a completely interconnected urban mobility ecosystem where scheduling becomes possible and a unified schedule system, by integrating the data of multiple sources, will enable transitions between transport forms to become seamless. The passengers will have real-time, cross-platform updates of the best available traveling options so that they see minimum wait times and avoid congestion throughout the urban transportation system. This would give the maximum improvement in users' experience and help lead to a more sustainable urban transport system.

Incorporation of Environmental and Social Data

The next iteration of the system may involve integration of environmental and social data for further optimizing the transportation service. For example, the weather current conditions and air quality are integrated in the model while predicting passenger demand and scheduling the buses regarding these two elements. Such special events or social causes like public holidays and others local events are taken under consideration in the surge in demands. In turn, taking such additional data points into consideration makes the system refine its prediction

and even make the public transportation network more adaptive and responsive to the public needs. That way, besides increasing the satisfaction level among users, it would be possible to reduce the carbon footprint of the city due to minimal deployment of buses during the low demand hours.

CONCLUSION

This study indicates that with machine learning and the use of real-time data, optimization of public transport timetables can be improved. The intelligent bus stop integrated with sensors and display monitors gave information on a real-time basis to passengers waiting at the stops. Besides, dynamic schedule updates through system adaptation in real-time for passenger demand as well as traffic conditions lowered wait times as well as costs incurred. The other major advantage is that the optimization of bus routes brought down the emissions and fuel utilization. This is a step towards the development of smart transportation systems for cities supporting dynamic changes in traffic flow. Future developments could include scaling up to larger municipalities and integrating the system with more types of variables like weather and public events, thereby improving the accuracy in time predictions.

ACKNOWLEDGMENTS

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AI Driven Tool Wear and Product Quality Monitoring System using IoT

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ABSTRACT

Lathe machining is widely used in manufacturing cylindrical components, but tool wear significantly affects machining efficiency and product quality. Traditional tool wear monitoring methods, such as visual inspection, are time-consuming and unreliable. This research proposes an AI-driven tool wear and product quality monitoring system using IoT. Sound decibel sensors placed near the cutting tool capture noise levels, which are analyzed to predict tool failure and bluntness. Machine learning models, developed using statistical tools like Minitab, process sound data alongside machining parameters such as feed rate, cutting speed, and material type. Real-time data transmission is enabled via an ESP8266 Wi-Fi module, and analysis is performed on the Blynk IoT platform. The system aims to enhance predictive maintenance, minimize downtime, and improve machining efficiency, thereby making manufacturing more cost-effective and sustainable.

KEYWORDS : *Tool wear monitoring, IoT, Machine learning, Predictive maintenance, Sound sensors.*

INTRODUCTION

Industry 4.0 integrates AI, IoT, and machine learning into manufacturing, transforming traditional processes into data-driven, intelligent systems. Lathe machining remains a critical manufacturing process for producing cylindrical components, but tool wear significantly impacts efficiency and product quality.

As cutting tools wear due to friction and heat, defects such as dimensional inaccuracies and increased surface roughness arise, leading to higher production costs. Conventional monitoring methods, such as visual inspections and scheduled maintenance, often fail to provide real-time insights, resulting in unexpected tool failures and unplanned downtimes.

Recent advancements in AI and IoT have enabled real-time monitoring of tool wear. IoT-enabled sensors continuously collect data, while AI algorithms analyze wear patterns to

predict tool failures. This study proposes an AI-driven IoT system that utilizes sound decibel sensors to track tool wear, reducing dependency on manual inspections and improving decision-making. By integrating real-time data processing and predictive analytics, this system enhances machining efficiency and ensures cost-effective maintenance strategies.

LITERATURE REVIEW

Existing Research on Lathe Machine Automation

Parmar and Mehta (2014) explored the automation of lathe machines, highlighting how advanced technologies can be integrated to improve operational efficiency. They developed a system that allows machinists to control various parameters of the lathe, including temperature regulation and remote shutdown, thus optimizing the machine's operations and reducing the chances of human error. This research aligns with the current project by

emphasizing the importance of automation and data-driven decision-making in improving lathe machine performance.

Abd-Alrazzaq et al. (2019) proposed a CNC multi-pass spinning solution for retrofitting traditional lathe machines. By integrating computer numerical control (CNC) into the lathe machines, the study demonstrated how modern technologies could enhance the efficiency, precision, and flexibility of operations. This research supports the project's objective of improving lathe machine performance through the integration of advanced technologies.

Intelligent Systems for Lathe Process Optimization

Sakthi et al. (2018) developed a semi-automatic lathe system using intelligent soft computing techniques, which contributed significantly to improving the precision and automation of lathe operations. By integrating soft computing approaches like fuzzy logic and genetic algorithms, the system adapted to varying machining conditions and optimized the cutting process. This research demonstrates how intelligent soft computing techniques can enhance both the accuracy and reliability of lathe machines, enabling more efficient manufacturing processes.

Zhang et al. (2018) investigated the use of acoustic emission (AE) sensors for real-time monitoring of cutting tool wear in CNC machines. Their research showed that AE sensors could detect tool wear early by capturing changes in sound signals during the cutting process. The study suggested that AE-based monitoring systems are effective for early fault detection, helping prevent tool failure and reduce operational downtime. This research provides valuable insights into the effectiveness of acoustic emission sensors for tool wear detection, which is a key component of the proposed system.

Summary of Related Research

Reference	Focus Area	Key Findings
Parmar & Mehta (2014)	Lathe Automation	Automation improves efficiency, remote monitoring enhances control
Abd-Alrazzaq et al (2019)	CNC Retrofit	CNC integration improves flexibility and precision

Sakthi al. (2018)	Soft Computing in Lathe Machines	Fuzzy logic and genetic algorithms optimize machining process
Zhang al. (2018)	AE-Based Tool Wear Monitoring	Acoustic emission sensors effectively detect tool wear

This literature review highlights the various advancements in lathe machine automation, intelligent optimization, and real-time monitoring. These studies support the proposed research by demonstrating the effectiveness of AI, IoT, and acoustic sensing in enhancing machining efficiency and predictive maintenance.

Existing research on tool wear monitoring highlights the limitations of traditional inspection methods and emphasizes the potential of AI and IoT integration. Studies have demonstrated that machine learning models, when trained on sensor data, can predict tool failure with high accuracy. IoT-enabled predictive maintenance significantly reduces downtime and enhances machining efficiency. Previous works have primarily focused on vibration sensors; however, sound sensors provide a non-intrusive alternative with promising results.

METHODOLOGY

The methodology for the tool wear monitoring system involves the design, implementation, and analysis of a system that uses sound levels to assess tool condition in lathe machining operations. The following steps outline the approach taken in the development of the system, data collection, and subsequent analysis.

System Design and Implementation

The first phase involved selecting and integrating the required hardware components, which include the ESP8266 Wi-Fi module, sound level sensor, OLED display, and a breadboard for prototyping. The sound sensor is strategically placed on the lathe machine's tool post to capture the vibrations and acoustic signals generated during machining. The data collected from the sensor is then transmitted via Wi-Fi to the Blynk IoT platform using the ESP8266 module. The real-time data, including sound levels, is visualized both locally on the OLED display and remotely on the Blynk mobile app.

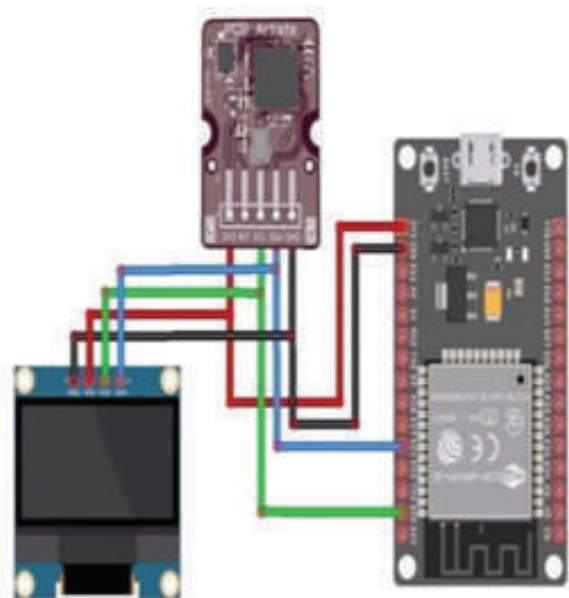
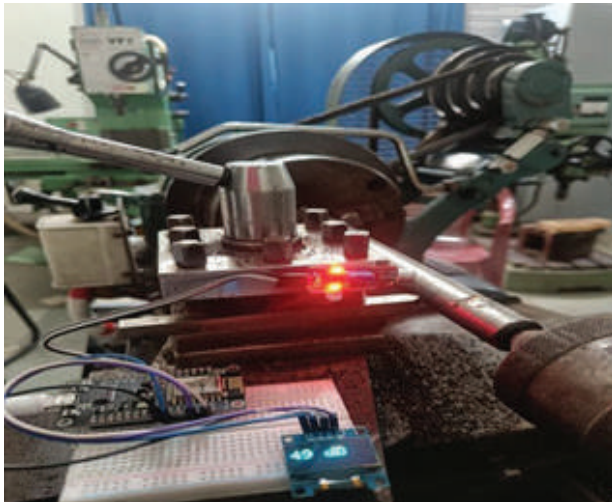


Figure showing sensor setup connections



Sensor Placement on Lathe Machine

Data Collection and Storage

The data collection process was set up to monitor key parameters such as sound levels (measured in decibels), feed rate, speed, and tool status. The sound sensor data, along with the machine's operational parameters (e.g., feed rate, speed), were continuously monitored and transmitted to the cloud-based Blynk platform. The Blynk app allowed real-time visualization of the data and notifications for tool wear or failure events. The collected data was exported from the Blynk platform in CSV format for further analysis.

Data Analysis using Minitab

Once the data was collected and stored, Minitab was used for regression and classification analysis to predict the tool's condition. The following steps were followed in the analysis:

- 3.3.1 Data Exploration and Descriptive Statistics: The initial step involved exploring the data through descriptive statistics to identify any patterns or outliers.
- 3.3.2 Regression Model Development: Linear regression was employed to predict the status of the tool (Sharp, Blunt, or Failure) based on parameters such as sound level (decibels), feed rate, speed, tool material, and workpiece material.
- 3.3.3 CART Model Development: A Classification and Regression Tree (CART) model was built for binary classification (Normal or Blunt). This model helped determine the conditions under which the tool is likely to fail based on real-time parameters.
- 3.3.4 Model Validation: The models were validated using cross-validation techniques to ensure their reliability. The accuracy, precision, and recall of both the regression and CART models were calculated.
- 3.3.5 Prediction and Export: After validating the models, predictions were made for new data points, and the results were exported in CSV format for reporting and further use.

Cloud Integration and Mobile Application

The data collected from the sensor was continuously updated on the Blynk platform, which provided a secure cloud-based environment for storing and visualizing the data. The mobile application interface allowed users to view real-time graphs, receive alerts, and analyze trends to monitor tool wear effectively. Custom widgets were created on the Blynk app to display the sensor data, including real-time sound levels, and provide notifications about tool failure or wear.

Specifications Hardware

- Sound Level Sensor: 30-130 dB range, analog output
- ESP8266 Wi-Fi Module: 3.3V, 802.11 b/g/n, 72.2 Mbps data speed
- OLED Display: 0.96" I2C interface, 128 x 64 resolution, 3.3V-5V
- Microcontroller: Arduino Uno, 5V, 14 digital I/O pins

Software

- Programming: Arduino C++, Minitab for analysis
- Cloud Platform: Blynk for real-time data, CSV export
- Mobile App: Blynk for monitoring and alerts.

System

- Power: 5V DC for components, 3.3V for sensors
- Connectivity: Wi-Fi (ESP8266) to Blynk platform

RESULTS AND DISCUSSION

The following data is collected from blynk and it is subjected to MINITAB analysis

Tool material	Workpiece material	Feed rate(mm/r ev)	Speed (rpm)	Decibel(dB)	Failure time(min)	Tool condition
HSS	Aluminum	0.05	1200	75	60	Sharp
HSS	Aluminum	0.10	1000	80	120	Sharp
HSS	Mild Steel	0.15	800	85	150	Blunt
Carbide	Mild Steel	0.10	1500	90	180	Blunt
Carbide	Aluminum	0.20	1300	95	200	Blunt
Ceramic	Titanium	0.05	1800	100	100	Failure
HSS	Copper	0.08	1100	85	90	Sharp
Carbide	Aluminium	0.18	1400	95	220	Blunt
Ceramic	Mild Steel	0.10	1500	100	280	Failure

Data Analysis and Results**Analysis of Decibel (dB) vs. Speed (RPM)**

This section looks at the relationship between speed (RPM) and decibel level (dB), which is a measure of the noise produced by the tool while cutting.

Regression Equation

Decibel (dB) = 46.62 + 0.03529 Speed (RPM)

Table 1

Term	Coefficient (Coef)	Standard Error (SE Coef)	T-value	P-value	Variance Inflation Factor (VIF)
Constant	46.62	9.40	4.96	0.003	
Speed (RPM)	0.03529	0.00705	5.00	0.002	1.00

Model Summary

- S (Standard Error of Estimate): 5.81580
- R-squared (R^2): 80.67%
- Adjusted R-squared (R^2 adj): 77.45%
- Predicted R-squared (R^2 pred): 58.33%

Analysis of Variance (ANOVA)**Table 2**

Source	DF (Degrees of freedom)	Adj SS (Adjusted Sum of Squares)	Adj MS (Adjusted Mean Square)	F-Value	P-Value
Regression	1	847.1	847.06	25.04	0.002
Speed (RPM)	1	847.1	847.06	25.04	0.002
Error	6	202.9	33.82		
Total	7	1050.0			

Explanation

- According to the regression equation, the decibel level rises with increasing speed (RPM). The decibel level rises by 0.03529 dB for every unit increase in RPM. This implies that greater noise is often produced at higher cutting speeds.
- The R-squared value of 80.67% indicates a significant correlation, with changes in cutting speed accounting for 80.67% of the variance in decibel levels.
- The influence of speed on decibel level is statistically significant, as indicated by the p-value for Speed (RPM) of 0.002, which is below the usual cutoff of 0.05.
- The ANOVA demonstrates that the regression model fits the data well, with the p-value being 0.002 and the F-value of 25.04 being considerably more than 1.

Key Takeaways

- The decibel level rises with increasing cutting speed. This suggests that greater friction and tool wear at higher speeds result in more noise.
- A considerable amount of the fluctuation in decibel levels can be explained by the model, which is statistically significant.

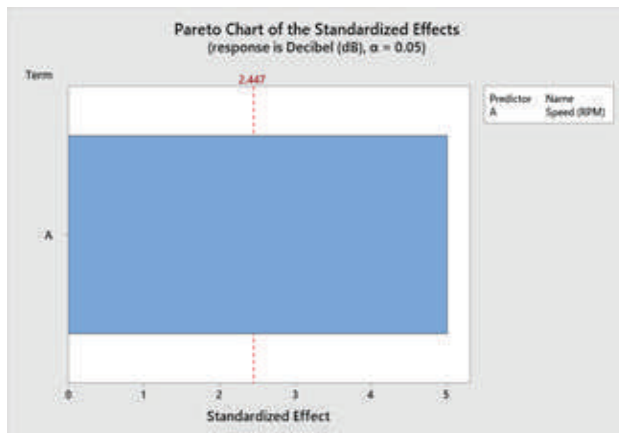


Fig. 2: Pareto Chart to Predict speed (RPM)

Application to Other Parameter Combinations

Similarly, the analysis conducted on Decibel vs. Tool Condition can be extended to other parameter combinations for a more comprehensive understanding of tool wear and failure patterns. For example, by analyzing Speed vs. Failure Time, we can observe how variations in spindle speed affect the time it takes for the tool to fail. A graphical representation such as a scatter plot can reveal whether higher speeds correlate with quicker tool degradation.

Additionally, combinations like Feed Rate vs. Tool Wear can be studied to see how different feed rates impact the sharpness or bluntness of the cutting tool. Speed vs. RPM could show the relationship between the spindle speed and the rotational speed of the tool, which could affect the wear rate differently across various tool materials. Decibel vs. Speed can also be plotted to observe if increased speed results in higher noise levels, indicating higher wear and tear.

Each of these combinations can be visualized using scatter plots, line graphs, or bar charts, depending on the nature of the data. Further statistical analyses like correlation or regression can help quantify the strength of relationships between these parameters, providing valuable insights into optimizing machining conditions and tool life.

CONCLUSIONS

This study presents a comprehensive approach for monitoring and predicting tool wear in lathe machining operations through real-time sound analysis, utilizing an IoT-based system powered by the ESP8266 Wi-Fi module, specialized sound level sensors, and the Blynk IoT platform. The goal was to enhance operational efficiency,

minimize downtime, and ensure consistent product quality by detecting tool wear and failure early, without the need for direct contact with the cutting tool.

The system's real-time data collection and transmission to the Blynk platform allows operators to remotely monitor the condition of the cutting tool and receive timely notifications about potential failures. The analysis conducted using various combinations of parameters, such as Decibel vs. Tool Condition and Feed Rate vs. Tool Wear, provided valuable insights into the tool's degradation patterns, enabling predictive maintenance and helping avoid unexpected downtimes.

Additionally, regression and Classification and Regression Tree (CART) models were employed to predict tool wear and failure based on parameters like feed rate, speed, tool material, and workpiece material. The results indicate that these models can significantly improve the accuracy of predicting tool status, making them a reliable tool for manufacturers aiming to optimize their maintenance schedules.

The flexibility and scalability of the system allow it to be adapted to different lathe models and machining processes, making it a viable solution for various industries. The ability to collect real-time data and visualize it on mobile devices or web interfaces enables proactive decision-making, contributing to improved operational efficiency.

In conclusion, the proposed tool wear monitoring system offers a cost-effective, scalable, and efficient solution to monitor tool condition, predict failures, and optimize machining operations. This system, by incorporating sound analysis and IoT technologies, marks a significant step toward the adoption of smart manufacturing practices, where real-time monitoring and predictive analytics play a crucial role in enhancing productivity and minimizing maintenance costs.

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Experimentation on Finned Tube Adsorber Bed Heat Exchanger Employed as Thermal Compressor in Adsorption Refrigeration System

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ABSTRACT

A laboratory-scale experimental setup of a double-bed adsorption refrigeration system has been designed, employing silica gel as the adsorbent and water as an eco-friendly refrigerant for cooling purposes. This research investigates a cooling capacity of 0.5 TR, with hot water in the temperature range of 45°C to 65°C serving as the heat source, while ambient-temperature water functions as the cooling medium.. The system delivers chilled water as the final output. Adsorber bed heat exchangers utilized as a part of the system goes about as a 'Thermal compressor'. The Adsorber bed warm exchangers are composed and manufactured such that, the heat and mass exchange rate is to be as high as could be expected under the circumstances and heat resistance are to be as low as would be prudent. The system includes a Mass Transfer Channel (MTC), which features an integrated structure consisting of multiple copper tubes with circular aluminum fins attached to the tubes to maximize heat and mass transfer efficiency. A thin layer of silica gel is applied around the copper tubes to minimize thermal resistance and enhance heat transfer.. Binder PVAC is utilized to fill the silica gel in space between balances around the MTC to hold the substance and encased in a sealed external packaging. The framework is examined through the arrangement of examinations against various working conditions to get the execution parameters as, Specific Cooling Power (SCP) and Coefficient of Performance (COP). A reliable and modern methodology is adopted to reduce experimental errors. The impact of various operating conditions on performance parameters is examined using graphical tools, offering a clearer understanding of the system's overall behavior.

KEYWORDS : Adsorption refrigeration system, Adsorber bed, Mass transfer rate, Adsorbent.

INTRODUCTION

Substantial quantity of energy in the form of heat is dumped in atmosphere from the utilities such as Internal combustion engines [1], [2] and thorough the process heating industries [3]. Numerous researchers have explored ways to harness waste heat for powering refrigeration systems, with adsorption bed-based refrigeration emerging as one of the most promising technologies in recent decades due to its effective

utilization of waste heat. Due to the advantages such as nontoxic nature, no rotating part hence less noisy and easy operation, adsorber bed-based refrigeration system makes its way front from traditional VCR system where readily waste heat is available, in places such as hospitals and commercial buildings[1].

As the focus of world is shifting to the sustainable utilities to achieve the SDGs and to govern the global warming[4] and depletion of Ozone[5], a refrigeration system utilizing

an adsorber bed contributes to sustainable development by offering an environmentally friendly alternative, as it avoids harmful substances and efficiently harnesses waste heat from readily available sources. While using this system it is likely to have leakage if the water based system is used as it is to be operated in vacuum[6]. The energy usage matrix of the globe shows us that the major part of the energy in today's world is utilized by HVAC systems which has very high GWP and ODP substance incorporated in them[7][8]. Adsorber beds can be powered by variety of waste heat sources ranging from 400C to 4000C. This system is most suitable for environments with significant vibrations, such as fishing boats [9] and locomotives[10].

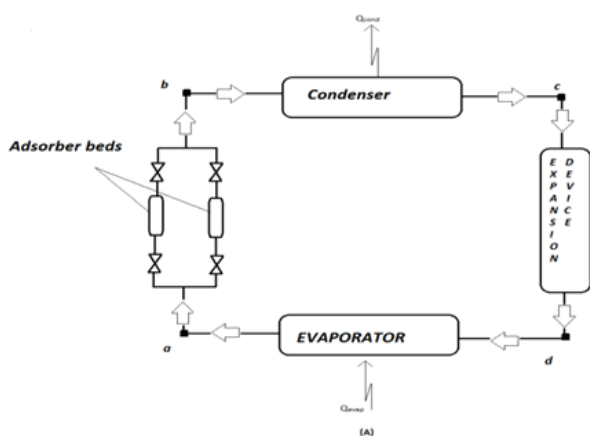


Fig. 1 Basic layout of Adsorption refrigeration system

Adsorber Bed Heat Exchanger

As per the general intuition that heat and mass transfer rate in the heat exchanger is at most important, so it is important to adopt such configuration of the heat exchanger which has a maximum area of heat transfer as well as lowest thermal resistance to the flow of Adsorbate over the Adsorbent. There are so many configurations of heat exchangers available and used before by many researchers. Prior to information, Amir Sharafian et al. [12], briefed about the different design of adsorber bed that were utilized in the technologies based on the principle of adsorption, they also described the design on basis of COP, SCP AAMR. Following types of designs were studied by the author are Spiral plate type, Shell and Tube type, Hair-pin type, Annulus tube type, Plate-fin type, finned tube type, Plate tube type, simple Tube type, and simple Plate type, as shown in the figure above. Amongst all these configurations, highest COP, and SCP is reported for the finned tube type heat exchanger. With this

analysis, it is decided to go with finned tube Adsorber Heat Exchanger so that we can assure higher heat and mass transfer rates. The design of finned tube Adsorber bed heat exchanger includes a heat transfer tube of material having higher thermal conductivity and it is surrounded by extended surfaces which increase surface area. The adsorbent material is packed into the spaces between the fins surrounding the heat transfer tubes and is secured in place using polyvinyl alcohol as a binding agent. This section is called as 'Mass Transfer Channel (MTC)' and now the whole assembly is enclosed in the outer casing so that it would be subjected to vacuum.

Selection of Adsorbent-Adsorbate Pair

Adsorbent-Adsorbate pair combination is an important aspect of mass transfer inside the adsorber bed. It has been decided to use the hot water with temperature range 800C to 900C. Hence, while selecting the suitable Adsorbent and Adsorbate, it is important to ensure that, regeneration of an Adsorbent material is in between this temperature range.

Selection of material and other parameters of main components

As per the design, finned tube Adsorber bed consists tubes of copper surrounded by circular fins which is then fixed in the contained using the arrangement of flanges. Selection is as follows –

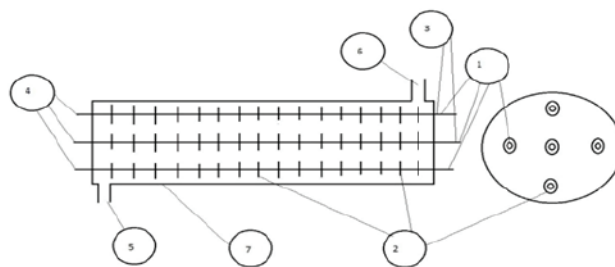


Fig 2 Line diagram of an Adsorber bed Heat-Exchanger
Description:- (1)Mass transfer channel (2) adsorber bound copper fins (3) Mass transfer inlet (4) Mass transfer outlet (5) Refrigerant inlet (6) Refrigerant outlet (7) Outer shell with insulator

- Material used for tubes– copper (higher thermal conductivity and easy availability)
- Orientation – coiled tubes (5 tubes – to assure maximum heat transfer)
- Diameter of tube – 3/8" (9.54 mm)

- Shape - Circular
- Length – 300 mm
- Fins:
- Type - Circular fins
- Material – aluminum
- Thickness of each fin – 0.5 mm
- Dimension of single fin –
(Diameter * thickness) cm = $5 * 0.05$ cm
- Space between two fins – 10 mm
- No. of fins on one tube- 48

Outer casing

- Material – G.I. Sheet
- Dimensions - (Diameter * height) cm = $(30 * 60)$ cm

Condenser

- Air-cooled
- Tube material – copper

Capillary tube

- Diameter – 2 mm
- Length – 60 cm

Evaporator

- Material of outer body – Aluminum sheets
- Shape – Rectangular Box
- Plate type evaporator
- There are two openings for the evaporator, one passes liquid Adsorbate from expansion capillary to evaporator, and one passes vaporized Adsorbate to Adsorber bed for adsorption

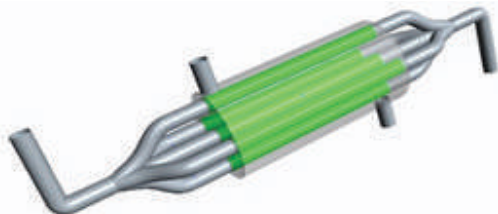


Fig. 3 Modelling of Adsorber bed CATIA V5 R20



Fig. 4 Pictorial view of adsorber bed

RESULTS AND DISCUSSION

Experimentation is conducted with the primary objective of determining performance parameters. Experimentation is a standard system tool after to acknowledge working of a specific process or marvel. Here, a cooling framework considering the standard of Adsorption is tried for various cases and perceptions are recorded in the perception tables. Experimentation performed on the test apparatus and safety measures are taken to limit blunders. In this section, a complex execution technique is talked about which is adjusted to lead experimentation. The investigation is led for three unique situations where starting conditions shift while marvel continues as before.

Results summarized in the manuscript are derived from the experimental analysis of the test rig compromising of two adsorber bed for continuous operation of utility. Analytical study if conducted to interpret the effect of various operating parameters on the performance of the system. Graphical tools are used to see the trends of operating parameter change effects on the performance parameter.

From the above figure, when we hold the cycle time as a constant parameter the COP follows same pattern for any of input value of temperature. Smooth and hassle-free operations were observed for 45°C of the temperature of a hot fluid. The COP values reach their peak at 65°C, however, the trend appears inconsistent at lower mass flow rates. When the hot water flow rate exceeds 10 LPM, the

COP remains consistent regardless of input variations, making it optimal to maintain the mass flow rate between 10 and 15 LPM.

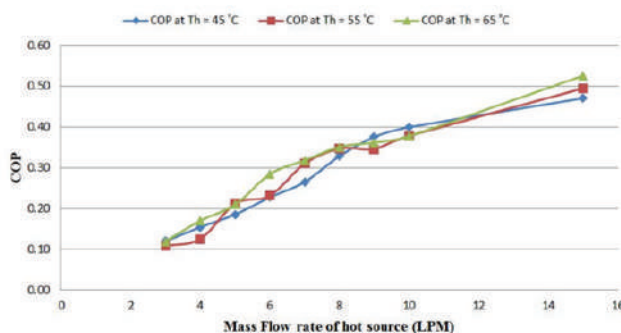


Fig. 5 COP trends for variable mass flow rate

SCP's vs variable Mass flow rate of the hot source

Among all three patterns, it is evident that SCP increases linearly with the rise in mass flow rate, as depicted in the figure above. At lower mass flow rates of the hot source, SCP remains minimal. Up to a mass flow rate of 10 LPM, predicting the trend of SCP increase is challenging due to slight variations in evaporative power. However, when the hot source mass flow rate exceeds 10 LPM, greater heat transfer occurs within the heat exchanger. This results in a significant temperature drop in the evaporator, leading to enhanced cooling.

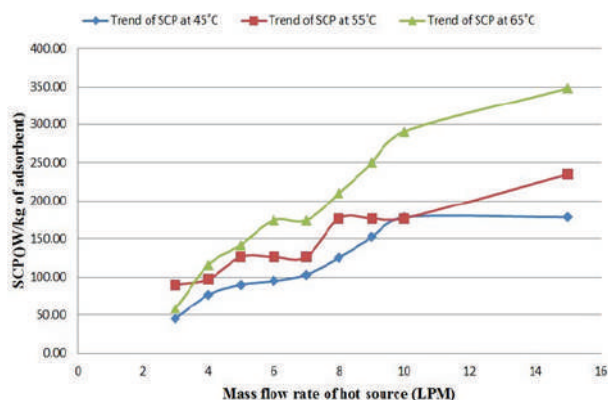


Fig. 6 SCP's vs variable Mass flow rate of the hot source

This infers increment in cooling power. Refrigeration system intended for 0.5 TR limit is well n great when it accomplishes SCP around 350 W/kg of adsorbent. At a mass flow rate of close around 15 LPM and hot source bay temperature of 65 °C, the system accomplishes SCP around 360 W/kg of the permeable. It is practical to work the system in this range to get successful SCP.

CONCLUSIONS

This project explores tentatively the execution of cooling framework in view of the wonder of Adsorption. Execution parameters like SCP and COP are ascertained, in view of which test examination is finished. Taking after conclusions can be made through compelling work on the project.

Experimentation model of Adsorption Cooling System has been produced

In this venture, Device and approach for the development and working of double bed Adsorption Refrigeration system operable with water as an eco-friendly Adsorbate and silica-gel as an adsorbent are developed. The system consists of an adsorber bed, condenser, expansion device (capillary tube), and evaporator as the primary components. An additional setup includes hot and cold water tanks along with pumps.

Design and Fabrication of an Adsorber bed heat exchanger

The plan of Adsorber bed heat exchanger given at most significance, since poor outline prompts low estimations of execution parameters. Here, more concentrate is made on the change in heat and in addition mass exchange rates. As per this, Adsorber bed is composed and manufactured. The heat transfer rate of the heat exchanger is improved by increasing the heat transfer area. The mass transfer rate is enhanced by reducing the resistance between the adsorbent-adsorbate particles using a binder. Silica gel (adsorbent) material is properly placed between the circular fins with the help of a binder, thus optimizing the adsorber bed heat exchanger for better performance.

Specific Cooling Power (SCP) and Coefficient of Performance(COP) is straightforwardly corresponding to the mass flow rate of the hot source

As the mass flow rate of hot source builds, heat exchange rate inside the Adsorber bed heat exchanger increments. SCP and COP increment with an increase in mass flow rates and gets settled after a few estimations of mass flow rates at specific process duration. At a process duration of 15 minutes, which is widely accepted for freezer cooling, the mass flow rate of the hot source is maintained at approximately 15 LPM of water. At this estimation of mass flow rate, most extreme COP's and SCP's are watched. Afterward, COP and SCP values stay consistent (exceptionally minimal change) regardless of

the possibility that mass flow rate expanded. At around 65 °C of the gulf temperature of hot source and 15 min. of process duration, COP acquired is around 0.55 while, SCP is around 348 W/kg of adsorbent.

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Carbon Credits Overview: History, Present, and Upcoming Challenges

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ABSTRACT

Ever since the dawn of the industrial revolution, we have been using fossil fuels in an ever increasing amount. Gradually as our understanding of the Earth system developed, we began to understand the repercussions of our actions; that the greenhouse gas emissions are causing a harmful change to the Earth's climate. From that realization, arose the need to revert the ill effects of our actions. In this review paper we trace back how the idea of taxing greenhouse emissions came into being, and how it evolved over time. We also provide a technical as well as public activism perspective to the events that helped shape the global legislation around carbon trading. Finally, we review the challenges that we face as a nation to thrive in the carbon trading economy. We discuss how addressing these challenges as opportunities will get us onto a strong footing on our path of sustainable economic development.

KEYWORDS : *History of carbon credits, Greenhouse effect, Green finance, Carbon trading, Implementation challenges, Feasible implementation approach.*

INTRODUCTION

That the atmosphere and different gasses trap heat in varying proportions was well known since the late 19th century. Researchers such as John Tyndall did pioneering work to measure infrared radiation absorption by various gasses. In the 1860's he was able to demonstrate that very small proportions of some gasses such as water vapour, carbon dioxide (CO₂) and hydrocarbons in the atmosphere have a disproportionate effect on infrared absorption. It is now known that such infrared absorption by the atmosphere results in rising of the surface temperature of the Earth. This effect was further quantified by Svante Arrhenius who in 1896 first made quantitative predictions of this warming effect of the Earth due to change in atmospheric concentration of carbon dioxide [1]. This phenomenon was named as the "greenhouse effect" based on the glass greenhouses that were built to raise plants in winters in cold countries.

Global temperature record keeping began in 1850 and early 20th century observers had also realized that the global average temperatures were rising since the 1900's. Scientists were also measuring the proportion of various gasses in the atmosphere and had observed that the concentration of carbon dioxide was rising. Although

a correlation existed between carbon emissions and rising global temperatures, causality had not yet been established.

There were different views regarding atmospheric warming. Prominent amongst the views was that of the "Ice Age theory".

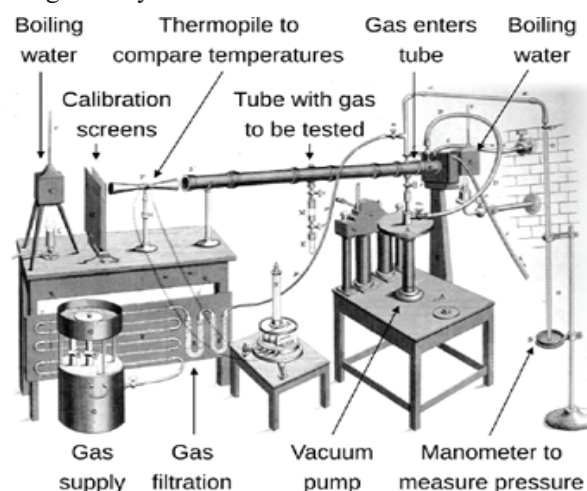


Fig. 1: John Tyndall's ratio spectrophotometer; Used to measure proportion of infrared radiation that was absorbed and emitted by different gasses. (Courtesy – Wikipedia)

It had been discovered that the Earth had gone through several cycles of warming and freezing. Correspondingly, the Earth had passed through several intermittent ice ages in which colossal ice sheets covered the planet from the poles to the tropics. These ice ages were spaced by warm periods in which fossilized tropical vegetation had been found at higher latitudes. While the reasons for such extreme cycles were not known, it was assumed that the Earth is in the middle of one such warm cycle and hence the global temperatures were rising [2]. Further, any form of human intervention would not have a meaningful effect on global temperatures.

As the greenhouse theory had not been scientifically established, magazines such as Popular Mechanics equivocated on the different viewpoints.

SCIENTIFIC DEVELOPMENTS AND RISING AWARENESS

In 1966 Syukuro Manabe successfully modelled the Earth's climate as affected by the heat trapped by various gasses in the atmosphere for the first time. His work was so fundamental in developing our understanding of the Earth's climate system that Manabe was jointly awarded the 2021 Nobel Prize in Physics [3]. This was also the starting point where the scientific community started paying attention to the anthropogenic effects on Earth's climate, for Manabe had shown that it was not just the temperatures and local weather, but the global climate itself that was changing as a result of human industrial activity.

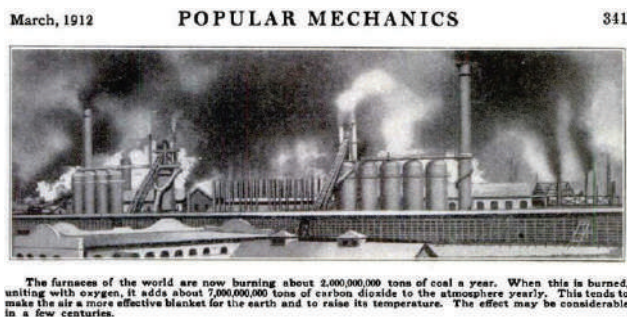


Fig. 1: A depiction from “Remarkable weather of 1911”, Popular Mechanics – March 1912, Pp 339-342

The ill effects of rapid and indiscriminate industrialization on the environment were becoming visible to the people and thereafter gradually governments started to take notice. As a response to this environmental degradation, the Clean Air Act (CAA) was enacted in the USA in 1963. In its initial form this law mandated the US

government to conduct a study of all substances that damage the stratosphere and particularly the ozone layer. As further evidence on ill effects of pollution mounted, several amendments were made to the CAA. The 1977 amendment to the CAA required new or modified sources of hazardous emissions to obtain government permits. In its earliest form, carbon credit trading owes its genesis to this amendment, as for the first time a law was enacted to regulate carbon emissions [4]. The 1990 amendment further strengthened the act to require mostly all major sources that emit or have the potential to emit 100 tons per year of any regulated pollutant to require permits. Even stricter standards were set for specific regions having material Ozone degradation.

GLOBAL ACTIVISM

By the early Nineties, the world was also waking up to the challenges of climate change. In 1992, the United Nations framework convention on climate change (UNFCCC) treaty was adopted. Its stated purpose was to stabilize atmospheric greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. The UNFCCC came into force in 1994 and provided the foundation for future multilateral agreements designed to combat climate change. Following this, the Kyoto protocol was adopted in 1997 and came into force in 2005. For the first time, an international treaty set legally binding targets on its signatories to reduce greenhouse gas emissions. Moreover, beyond clean development and joint implementation initiatives, it set up an international emissions trading mechanism. The Kyoto protocol planned to achieve its objectives in two phases or commitment periods; in the first (2008 through 2012) 37 industrialized countries committed to reduce greenhouse gas emissions to an average of 5% below 1990 levels. During the second commitment period (2013 through 2020) parties committed to reduce emissions by at least 18% below 1990 levels.

Meanwhile, further research was yielding even more compelling evidence. Mann, Bradley, and Hughes (MBH99) published reconstructed Northern hemisphere surface temperatures for the past 1000 years [5]. Climatologist Jerry Mahlman popularised the term hockey stick graph to refer to this reconstructed temperature pattern. Mahlman described the pattern as the ice hockey stick; where he visualised the relatively flat downward trending curve through 1990 as the shaft of the hockey stick and the sharp, steady increase in temperatures from

1990 onwards as the blade portion of the hockey stick. This approach brought the esoteric topic of climate change onto coffee tables. People gradually began to realize the effect climate change could have on their lives.

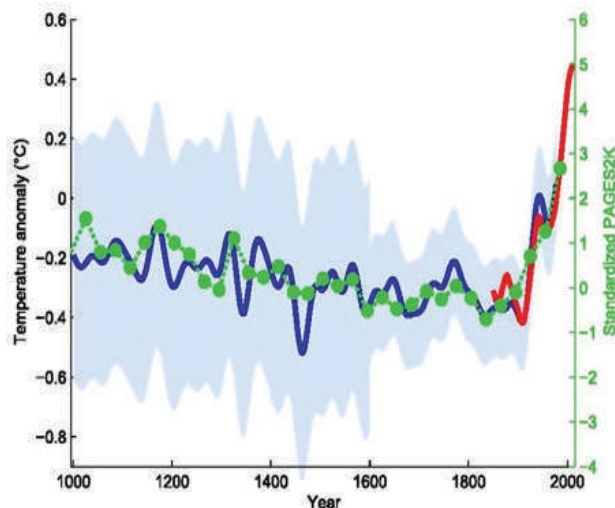


Fig. 2 : The original northern hemisphere hockey stick graph of Mann, Bradley & Hughes 1999, smoothed curve shown in blue with its uncertainty range in light blue, overlaid with green dots showing the 30-year global average of the PAGES 2k Consortium 2013 reconstruction. The red curve shows measured global mean temperature, according to HadCRUT4 data from 1850 to 2013.

TRADE TO REJUVENATE

The Paris Agreement superseded the Kyoto Protocol and came in force in 2016. Article 6 of the Paris Agreement provides the basis for the upcoming carbon markets [6]. At the 2024 United Nations Climate Change Conference – COP29, countries agreed to the complete realization of article 6 of the Paris Agreement. Amongst other provisions of climate financing this article provides for internationally accepted legal mechanisms to facilitate carbon trading. For the purpose of carbon trading, this is equivalent to setting up an international currency akin to the US dollar for monetary transactions.

The central idea of setting up such a carbon trading mechanism is to progressively penalize greenhouse gas emissions. To begin with, each signatory nation of the Paris agreement will distribute a given number of carbon credits every year to entities (industries) that emit carbon dioxide or other greenhouse gasses (GHG). The total number of carbon credits distributed by each nation shall be consistent with that nation's nationally determined

contribution (NDC) as committed at the Paris agreement, and hence will reduce year over year. Any given entity will be allowed to emit only so much of GHG as much as the carbon credits it has. Each Government shall set up compliance and monitoring mechanisms to enforce the emissions limit. If an entity needs to emit more GHG, it will need to buy an equivalent amount of carbon credits from the market.

This system promotes carbon efficiency as follows. If an entity emits a lesser amount of GHG than the credits allotted to it, then it may sell those excess credits in the carbon market. An entity can also earn credits by implementing green projects or processes that reduce GHG emissions as compared to the current standards. Further such GHG reducing projects may be implemented anywhere in the world. Thus a British company can earn carbon credits by investing in a wind energy generation project in India. The number of credits earned every year will be determined by the GHG emissions avoided by this green project when compared to an equivalent coal based power plant. The company can then either utilize those credits as per its needs or sell them in the global carbon market. Accurate and timely compliance monitoring and enforcement shall be the key to success in this endeavour.

The Carbon Credit

In the current system one carbon credit represents the removal from the atmosphere of or reduction in emission of one metric ton of carbon dioxide or equivalent. Do note that CO_2 is not the only pollutant of concern. Methane, another pollutant being copiously emitted by the oil and gas industry is a much more potent greenhouse gas. Beyond this other prominent greenhouse gases are:

- Nitrous oxide (NO_2): It is primarily released from industrialization of agriculture i.e. from the use of synthetic fertilizers.
- Hydro-chloro carbons: These gases are the refrigerants used in air conditioners and refrigeration systems
- Sulphur hexafluoride (SF_6): This is the most potent of major greenhouse pollutants with a global warming potential 23,500 times that of CO_2 [7]. Since this gas is only synthetically produced and is not a part of any natural cycle, it has no means of removal from the atmosphere. Thus, once this gas enters the atmosphere it will continue to contribute to the greenhouse effect for thousands of years. It is mostly used in the power industry – right from generation to distribution. The

use of this gas is permitted even in green sources of energy such as wind turbines.

Thus one carbon credit may refer to either one metric ton of CO₂, or to the equivalent amount of any other gas that has the same global warming potential of one metric ton of CO₂.

Some Progressive Features

Article 6 of the Paris Agreement, and specifically its subsection - article 6.2, provides the mechanism for a decentralized system for bilateral trading of carbon credits between two countries. Till now while such trades existed as bilateral agreements between countries, now they will gain international acceptance. Implementing this will require uniformity in all aspects of the trade – from definitions to the contract terms. Such trades will have the same look and feel as the trades on an equities market.

Realization of article 6.4 will lead to the development of a global carbon market in which carbon credits will be traded. Each signatory nation will be required to maintain registry services to track the carbon credits it issues. The European Union (EU) will set up and maintain the registry services for under- developed countries that are incapable of maintaining their own carbon credit ledgers.

This uniformity in structure and compliance, transparency, and ease of trading will facilitate international financing of GHG elimination projects.

THE INDIA SCENARIO

In India the penalty for using fossil fuels – especially derived from crude oil – had been inbuilt in the pricing of the fuel through indirect taxation. However, this taxation was not based on the carbon dioxide emitting potential of that fuel, rather on other factors such as availability, utility, and demand. Also, subsidies offered under various government schemes to agriculture, domestic, and other sectors incentivize carbon emissions as a detrimental side effect. Hence in the context of global warming, taxation of carbon emissions is required.

To address these issues and to formalize carbon trading in India the energy conservation act of 2001 was amended on 8 August 2022. The government plans to develop the Indian Carbon Market (ICM) to enable robust trading of carbon credits. As the first step, the government notified the carbon credit trading scheme (CCTS) in 2023. In addition to power intensive heavy industries, agricultural activities would also be included in CCTS. If implemented correctly

and rapidly, such inclusion of agriculture in CCTS could meaningfully increase the income of farmers in the country. For instance, it would incentivize farmers to use eco-friendly agriculture methods, not just for cultivation but also for agro waste disposal. Thus a farmer substituting synthetic fertilizers with organic ones would be eligible for earning carbon credits. Stubble burning is a major cause of pollution in northern parts of the country. A farmer could earn further carbon credits by avoiding stubble burning and instead utilizing the agro waste to produce valuable energy products. The possibilities range from producing wood gas and organic fertilizer in a bio-digester, to simply making wood briquettes used for cremation. These sustainable approaches to agriculture would have the dual effect of reducing the cost of cultivation as well as increasing the farmer's revenue by monetizing the agro waste as well as the carbon credits generated by offsetting emissions. The government has initiated concept development of this aspect of carbon trading by creating a framework for an agricultural voluntary carbon market [8]. The need of the hour is to quickly ramp up and bring agricultural carbon credits online in the ICM.

Challenges and Solutions

As with any new implementation, establishing the carbon credit regime will face growing pains. However, the primary issue that we should be cognizant of is encapsulated in the compromise that the EU reached with the US regarding carbon credits registry at the COP29 conference held at Baku, Azerbaijan in November 2024. During negotiations the US has ensured that a transaction “merely being recorded” on a carbon credits registry system does not automatically qualify as a UN endorsement of the credit. Additionally, the US has sought a higher level of autonomy over international carbon trading [9]. With the first measure, leading credit rating agencies may grade a carbon credit's quality as per both US and EU standards. The second measure enables the US to set its own standards regarding all aspects of the carbon credit trade.

As the world races towards a net zero carbon future, the standards setting bodies may be driven by different approaches and priorities. This could result in slight differences in standards, implying that Indian standards as well as compliance monitoring have to be at par or above both US and EU counterparts to ensure that projects in India continue to accrue internationally accepted carbon credits. Only then can we ensure the continuity of external

funding. While this could be an execution challenge, we do note that every challenge brings an opportunity with itself. Here we draw a parallel to the drugs manufacturing industry that caters to the US market. Just as those companies that meticulously adhere to US manufacturing standards reap rich rewards, the entities that are rigorous in their project compliance shall find the carbon trading system to be highly beneficial. The Government should make every effort right from standard setting to compliance monitoring – that integrity of the system is not compromised and thus enable ethical and conscientious entities to effectively contribute towards creating a developed nation.

CONCLUSION

In this paper we have briefly reviewed the global change in perspectives and policies towards greenhouse gas emissions from the beginning of the industrial era to the present. We retrace the steps through the gradual process the global community underwent towards accepting responsibility and mitigating the damage that has been inflicted. As nations prepare to transition to net zero economies, we have highlighted the prominent challenges and the accompanying opportunities. We suggest a minimalist approach by which we can convert those challenges into opportunities for the fastidious and fully utilize the benefits that flow in towards reducing our fossil fuel dependence.

Here, we have very briefly touched on various aspects concerning implementation of the carbon credit regime in the Indian context. There is much scope for further study in how best we could convert our existing processes and

transition our industry to a net zero carbon regime, while ensuring that our productivity and cost efficiency do not suffer.

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Study on the Range of Home Loan Options by Kotak Bank in Nagpur

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ABSTRACT

An in-depth investigation into the diverse home loan offerings provided by Kotak Bank in Nagpur reveals a comprehensive analysis of the various loan products designed to meet the financial needs of customers. With a growing demand for home loans, the bank has strategically developed a wide range of options, catering to different income groups, demographics, and individual requirements. The study evaluates loan features such as interest rates, repayment terms, eligibility criteria, processing fees, and additional services that set Kotak Bank's home loan schemes apart from competitors in the market. The research also delves into customer preferences and the impact of these products on homebuyers in Nagpur, highlighting the role of the bank's customer service and financial guidance in facilitating the home loan process. This study emphasizes Kotak Bank's innovative approach to home loan solutions, its efforts to promote affordable homeownership, and its market positioning in Nagpur's competitive banking landscape. Furthermore, the research considers economic factors, market trends, and customer feedback, offering valuable insights into how Kotak Bank tailors its home loan products to meet the evolving needs of potential borrowers. The findings contribute to a deeper understanding of home loan dynamics and offer suggestions for enhancing loan accessibility and affordability in the region.

KEYWORDS : Home loan options, Kotak bank, Nagpur, Financial products, Customer preferences, Eligibility criteria, Interest rates, Homeownership, Loan accessibility, Banking services.

INTRODUCTION

Home loans play a pivotal role in helping individuals achieve homeownership, a significant financial milestone for many. Kotak Bank, one of India's leading private-sector banks, offers a range of home loan products designed to cater to various customer needs. This research aims to analyse the diverse home loan options available at Kotak Bank in Nagpur, focusing on how these products align with the financial needs of prospective homeowners and the specific requirements of the local market.

The study seeks to understand the different types of home loan offerings provided by Kotak Bank, including loans for new homes, home renovation, and balance transfers. These products are tailored to provide flexibility in terms of repayment schedules, loan tenures, and interest rates. By analysing these options, the paper explores how Kotak Bank positions itself as a competitive player in Nagpur's home loan market.

In recent years, there has been an increasing demand for home loans, driven by rising property prices and growing aspirations of homebuyers. Kotak Bank has responded to this demand by designing home loan solutions that not only offer competitive interest rates but also aim to simplify the loan application and approval process. The research evaluates how these factors influence customer decision-making and the overall success of Kotak Bank's home loan products in the region.

A crucial part of this study involves exploring customer preferences, such as factors that influence their choice of home loan providers. Interest rates, processing fees, repayment flexibility, and customer service are essential elements in this decision-making process. Understanding these preferences allows Kotak Bank to fine-tune its offerings and enhance its market share while meeting the needs of diverse borrowers.

LITERATURE-REVIEW

The home loan market in India has witnessed significant growth, driven by a rise in disposable incomes and the increasing desire for homeownership. According to Sharma (2018), home loans have become a vital tool for many individuals, with financial institutions offering a variety of loan products tailored to different customer segments. Kotak Bank, known for its customer-centric approach, has contributed to this trend by providing diverse home loan options that aim to accommodate the varied needs of homebuyers. This literature review explores various studies that analyse home loan offerings and their impact on consumers.

Garg and Verma (2020) emphasize the importance of competitive interest rates in the decision-making process for potential homebuyers. They argue that while interest rates are a critical factor, the entire loan package, including processing fees and customer service, also significantly influences borrowers' choices. Kotak Bank's ability to offer low-interest rates and flexible repayment options has positioned it as a key player in the market. Their study highlights the need for banks to maintain transparency and provide a seamless borrowing experience to stay competitive.

A study by Kapoor and Sethi (2019) analysed customer satisfaction in the home loan sector, focusing on factors such as loan processing speed, eligibility criteria, and after-sales service. Kotak Bank's commitment to providing prompt approvals and personalized services has resulted in high customer satisfaction levels. This literature underlines the importance of efficient service delivery, which contributes to customer retention and enhances the bank's market positioning. As the demand for home loans grows, customer service remains a critical factor in maintaining a competitive edge.

METHODOLOGY

The research methodology for this study involves a descriptive research design, aiming to assess the various home loan offerings provided by Kotak Bank in Nagpur. The study primarily focuses on understanding customer preferences, loan features, and the effectiveness of these products in meeting the financial needs of potential homebuyers. Data will be collected from 100 participants who have either availed of a home loan from Kotak Bank or are familiar with the bank's offerings.

A structured questionnaire will be used to collect primary

data from the participants. The questionnaire will consist of closed- ended and open-ended questions, designed to gather insights on various factors influencing the decision-making process, such as interest rates, loan tenure, processing fees, and customer service experiences. The questions will also assess the satisfaction level of the customers with respect to their overall home loan experience.

The sample size of 100 participants will be selected using a convenience sampling technique. The participants will be selected from different segments of the population, including first-time homebuyers, individuals seeking home renovations, and those looking to transfer existing home loans to Kotak Bank. This will ensure a diverse representation of Kotak Bank's customer base in Nagpur, providing a more holistic understanding of the bank's home loan products.

Data will be collected through both online and offline methods. Online surveys will be distributed via social media platforms, email, and Kotak Bank's website, targeting individuals who are either existing or potential customers of the bank. Additionally, offline surveys will be conducted by approaching participants in branches of Kotak Bank in Nagpur to gather responses from those who may not be active on digital platforms.

To ensure the reliability and validity of the data, the survey instrument will undergo a pilot testing phase with 10 participants. This will help refine the questionnaire, address any ambiguities, and ensure that the questions are clear and easy to understand. Feedback from the pilot test will be used to make necessary adjustments before the actual data collection process begins.

OPPORTUNITIES & CHALLENGES

The home loan market in Nagpur presents numerous opportunities for Kotak Bank, primarily due to the growing demand for affordable housing. As urbanization increases, more individuals are seeking homeownership, making home loans a necessity for a large section of the population. Kotak Bank, with its competitive interest rates and flexible loan offerings, is well-positioned to tap into this demand. Additionally, the bank's focus on catering to a wide range of customers—from first-time buyers to those seeking home renovations—further enhances its market opportunities in the region.

One significant opportunity lies in Kotak Bank's ability to leverage digital platforms to enhance its service offerings.

As more customers embrace online banking, the demand for seamless digital loan application processes has risen. Kotak Bank has capitalized on this trend by providing an efficient online application system, making the home loan process quicker and more accessible. This shift toward digital solutions not only broadens the bank's reach but also helps it streamline operations, making it easier for customers to apply and manage their loans remotely.

Another opportunity for Kotak Bank is the increasing emphasis on affordable housing schemes promoted by the government. With several initiatives aimed at encouraging homeownership among lower-income groups, Kotak Bank can target this segment by offering tailored home loan products that align with these government policies. By providing low-cost loans with attractive repayment options, the bank can strengthen its position as a preferred choice for aspiring homeowners in Nagpur.

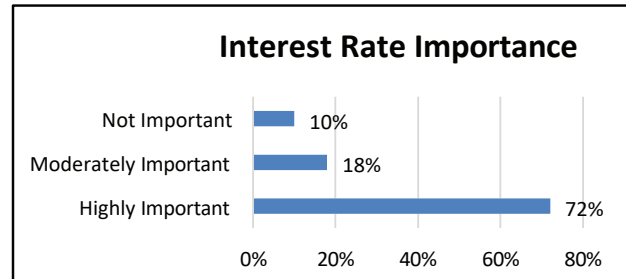
Along with these opportunities, Kotak Bank faces certain challenges in the competitive home loan market. One of the primary challenges is the intense competition from other financial institutions, particularly public sector banks, which often offer lower interest rates on home loans. This pressure to remain competitive can limit the bank's ability to significantly reduce rates without affecting profitability. Kotak Bank must balance customer affordability with its own financial objectives to remain a strong contender in the market.

Customer awareness is another challenge that Kotak Bank must address. While the bank has a strong brand presence, not all potential borrowers are fully aware of the range of home loan products available to them. Educating customers on the various options, eligibility criteria, and benefits of Kotak's home loan schemes is essential to ensure that the bank's offerings are considered by a wider customer base. Additionally, potential borrowers may be hesitant to switch from their current lenders, posing another challenge for Kotak Bank in terms of customer acquisition.

RESULTS AND DISCUSSION

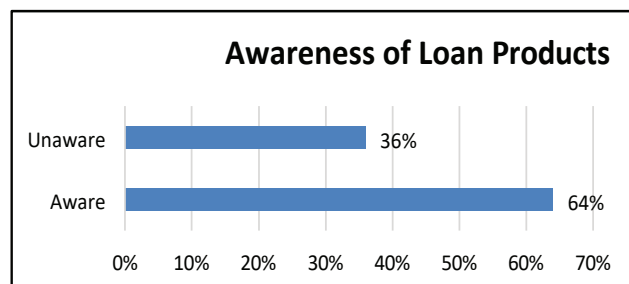
The results of the survey conducted on 100 participants reveal valuable insights into the preferences and behaviours of home loan customers at Kotak Bank in Nagpur. A significant 72% of respondents indicated that the most important factor in choosing a home loan is the interest rate, reflecting the importance of cost-effectiveness in loan decisions. This finding aligns with existing literature,

which suggests that interest rates are a key driver in home loan selection (Garg & Verma, 2020). The remaining 28% prioritized factors like loan tenure and repayment flexibility.



In terms of loan product awareness, 64% of the respondents were familiar with Kotak Bank's home loan offerings, while 36% were unaware of the variety of products available. This highlights an opportunity for the bank to increase awareness through targeted marketing efforts. Despite the relatively high awareness, it's clear that some customers may not be fully informed about all the available options, especially niche products designed for first-time buyers or home renovations.

Regarding customer satisfaction, 80% of the respondents expressed satisfaction with the overall loan application process at Kotak Bank. A major contributing factor to this positive feedback is the streamlined digital loan application process, which 70% of respondents preferred over traditional methods. This demonstrates that Kotak Bank's investment in digital solutions has significantly enhanced customer experience, making the loan application process quicker and more convenient.



A notable challenge that emerged from the survey is the perception of high processing fees. 55% of respondents identified processing fees as a deterrent when considering a home loan with Kotak Bank. Despite competitive interest rates, the additional costs associated with home loan processing can influence the overall cost of the loan, leading some potential borrowers to consider other financial

institutions offering lower fees. Addressing this concern could help Kotak Bank improve its competitiveness in the market.

On the topic of loan eligibility criteria, 65% of respondents indicated that Kotak Bank's eligibility criteria were reasonable and easy to meet, with clear documentation requirements. However, 25% expressed concerns about the strict credit score requirements, which they felt could be restrictive for some individuals. Kotak Bank's approach to maintaining robust credit evaluation standards ensures low-risk lending but might also limit accessibility for borrowers with less-than-perfect credit histories.

CONCLUSION

The study on Kotak Bank's home loan offerings in Nagpur reveals several key insights into customer preferences and satisfaction levels. Interest rates have emerged as the most significant factor in the decision-making process, with a majority of participants prioritizing cost-effective borrowing options. This finding underscores the importance of competitive interest rates in the home loan market and highlights Kotak Bank's strength in offering attractive terms.

While many respondents were aware of Kotak Bank's home loan products, there remains a gap in full awareness of all the available options, particularly those tailored for specific customer segments like first-time buyers or individuals looking to transfer loans. This points to an opportunity for Kotak Bank to invest in marketing strategies that increase the visibility of its diverse loan offerings, ensuring that all potential customers are informed about the range of products available to them.

The digitalization of the loan application process has significantly enhanced customer satisfaction. The ease and convenience of applying for loans online has been a key factor driving positive feedback. As digital platforms continue to gain prominence, Kotak Bank's emphasis on streamlining the loan process through technology positions it well to meet the growing demand for fast and efficient banking services.

Despite the positive response to the bank's home loan products, concerns about high processing fees were raised by a significant portion of the participants. While interest rates are competitive, the additional costs associated with loan processing may deter some potential borrowers.

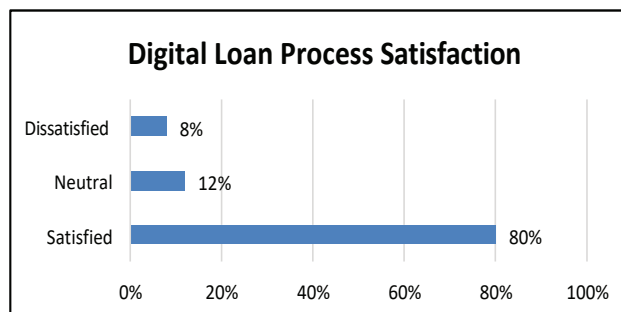
Addressing this concern by offering transparent and more affordable processing fees could make Kotak Bank's offerings even more appealing to a wider customer base.

Kotak Bank's eligibility criteria were generally deemed reasonable, though a portion of respondents found the credit score requirements restrictive. This highlights the need for the bank to consider more flexible lending policies, particularly for customers who may have a lower credit score but still demonstrate financial responsibility. This could help Kotak Bank tap into a broader market, increasing its reach among potential homebuyers.

Kotak Bank's home loan offerings in Nagpur are largely well-received, with high levels of satisfaction regarding the interest rates, digital services, and loan process. However, addressing challenges such as high processing fees and eligibility concerns could help further enhance customer acquisition and retention. By focusing on these areas, Kotak Bank has the potential to strengthen its position in the highly competitive home loan market.

FUTURE SCOPE

The future scope of Kotak Bank's home loan offerings in Nagpur is broad, with significant opportunities for growth and innovation. As the demand for homeownership increases in the region due to urbanization and population growth, Kotak Bank can expand its customer base by introducing more customized home loan products. By considering varying customer needs—such as loans for senior citizens, women, and first-time homebuyers—the bank could enhance its market share and cater to a more diverse clientele.



Technology-driven solutions present another area for growth. With digital banking becoming the preferred choice for many customers, Kotak Bank can further enhance its online platforms by integrating artificial intelligence (AI) and machine learning (ML) algorithms. These technologies can be utilized for more accurate

credit scoring, personalized loan recommendations, and improved customer service. Additionally, AI-powered chatbots can streamline the loan application process, making it even more user-friendly and efficient.

To improve customer acquisition and retention, Kotak Bank can explore partnerships with real estate developers and agents. These collaborations can facilitate special home loan offers for customers purchasing property from partnered developers, creating a win-win situation for both parties. Such strategic alliances would not only improve visibility but also attract customers looking for easy, bundled solutions for their home purchase and loan requirements.

Kotak Bank could also focus on financial literacy programs to increase awareness about home loans. Many potential borrowers in Nagpur may be unaware of the various loan options and their benefits. By offering workshops, seminars, or online content that educates consumers about the home loan process, interest rates, and repayment options, Kotak Bank can position itself as a trusted advisor in the home loan market.

The bank can explore the option of offering eco-friendly or green home loans. As environmental consciousness continues to grow among consumers, Kotak Bank could tap into this trend by providing loans with favourable terms for those purchasing energy-efficient or sustainable homes. This would not only align with global sustainability goals but also attract environmentally-conscious customers.

RECOMMENDATIONS

To enhance its home loan offerings in Nagpur, Kotak Bank should focus on improving product awareness and educating potential customers. While many respondents are aware of the bank's basic home loan products, there is a gap in understanding the full range of available options. By increasing efforts in advertising and conducting informative campaigns, Kotak Bank can ensure that all potential customers are aware of the various loan products tailored to different needs. This can be achieved through digital ads, informational workshops, and collaborations with real estate agents.

One key recommendation is for Kotak Bank to simplify its loan application process even further. While the digital loan process has been appreciated, there is still room for improvement in making the platform more intuitive. The

bank could invest in enhancing its mobile application and website, incorporating features such as real-time loan tracking, instant eligibility checks, and easy document uploads. This would provide a smoother and more seamless experience for customers, encouraging higher conversion rates.

Kotak Bank should consider offering special loan products targeted towards specific customer segments, such as first-time homebuyers, senior citizens, and women. These products could come with lower interest rates, flexible repayment terms, and reduced processing fees to attract and retain these segments. Introducing personalized loan solutions will not only improve customer satisfaction but also help Kotak Bank differentiate itself in a competitive market.

Addressing the issue of high processing fees is another critical recommendation. Based on the survey results, many customers are deterred by these additional costs, even if the interest rates are competitive. Kotak Bank could introduce a more transparent pricing structure, where the processing fees are clearly communicated upfront. Additionally, offering fee waivers or discounts on processing charges for certain loan types or eligible customer groups would make the loans more attractive to potential borrowers.

To further strengthen customer relationships, Kotak Bank should invest in customer service improvements. While the majority of respondents were satisfied with the loan application process, providing personalized and efficient customer support can go a long way in enhancing the customer experience. Implementing a dedicated support team for home loan applicants, offering live chat options, and ensuring quick response times to inquiries will help build trust and long-term loyalty.

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HR Practices and Appraisal Techniques at Reliance Retail Ltd

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ABSTRACT

Human Resource (HR) practices play a pivotal role in shaping the overall effectiveness of an organization, influencing not only employee engagement but also organizational growth. This study focuses on the HR practices and performance appraisal techniques employed at Reliance Retail Ltd., Nagpur, aiming to evaluate their impact on employee performance and organizational development. Through a combination of qualitative and quantitative research methods, the study investigates the effectiveness of various HR functions such as recruitment, training, employee development, and motivation. In particular, the research delves into the performance appraisal systems implemented within the company to assess how these techniques influence job satisfaction, employee morale, and overall productivity. By analysing data collected from employees and HR personnel at Reliance Retail Ltd., the study seeks to uncover the strengths and areas of improvement in existing HR practices and appraisal mechanisms. The findings highlight the importance of a transparent and fair appraisal process, the integration of employee feedback, and the alignment of HR strategies with organizational goals. Furthermore, the study emphasizes the significance of continuous development programs and performance assessments in ensuring a motivated workforce. Ultimately, the research aims to provide valuable insights and recommendations for improving HR policies and performance appraisal systems, contributing to enhanced organizational effectiveness and employee retention at Reliance Retail Ltd., Nagpur.

KEYWORDS : *HR practices, Performance appraisal, Employee engagement, Organizational development, Reliance retail ltd., Motivation, Job satisfaction, Workforce productivity, Employee retention, Human resource management.*

INTRODUCTION

Human Resource (HR) practices are integral to an organization's success, directly impacting employee performance, satisfaction, and overall organizational growth. With the rise of competitive markets, it has become essential for companies to adopt effective HR practices and performance appraisal techniques. Reliance Retail Ltd., Nagpur, as a leading retail organization, utilizes innovative HR strategies to attract, retain, and develop talent, ensuring a motivated and productive workforce.

Effective performance appraisal systems are crucial for aligning employee objectives with the organizational vision. These systems evaluate individual contributions and provide a structured framework for feedback, recognition, and improvement. In the case of Reliance Retail Ltd., Nagpur, understanding the relationship between HR practices and appraisal techniques is vital to enhance employee performance, job satisfaction, and career development.

The dynamic nature of the retail sector, Reliance Retail Ltd. faces constant challenges in managing its workforce effectively. Adapting HR practices to cater to a diverse workforce while ensuring consistency in performance management is essential. This research will explore how the company navigates these challenges, evaluating their strategies to ensure continuous growth and development for both the organization and its employees.

LITERATURE REVIEW

Effective Human Resource (HR) practices are fundamental in shaping organizational culture and driving business success. According to Armstrong (2016), HR practices such as recruitment, training, and development contribute significantly to employee satisfaction and performance. Companies with robust HR policies attract and retain talented individuals who can drive innovation and productivity. HR practices not only enhance employee capabilities but also align them with organizational goals, leading to long-term sustainability and growth.

Performance appraisal techniques are essential tools for assessing employee performance and providing feedback for improvement. In their study, Gupta and Kumar (2019) emphasize the importance of clear, objective, and consistent appraisal systems to avoid biases and ensure fairness. Transparent appraisal methods lead to higher employee engagement and motivation, as employees feel their efforts are recognized and valued. This feedback loop fosters an environment where continuous improvement is encouraged, ultimately benefiting both the organization and the employee.

In the context of retail organizations, the challenge of managing large, diverse workforces makes performance management even more critical. Singh and Sharma (2018) highlight that, in retail settings, regular performance assessments enable managers to identify skill gaps and provide targeted training. These practices not only ensure employees meet organizational standards but also enhance their job satisfaction and career growth. For companies like Reliance Retail Ltd., an effective appraisal system becomes a key driver in creating a high-performance culture and a competitive workforce.

Several studies have shown that integrating employee development programs with performance appraisals can lead to improved organizational outcomes. According to Jackson and Schuler (2017), linking performance appraisals with career development plans can boost employee morale and retention. Providing opportunities for skill enhancement and career progression helps employees stay engaged and committed to the organization, reducing turnover rates and fostering loyalty. This integration is especially beneficial in organizations with high employee turnover, such as retail businesses.

The effectiveness of HR practices in performance appraisal also depends on the organizational culture and management style. Sharma (2019) suggests that leadership's commitment to transparent and supportive appraisal processes can greatly influence the outcomes of such systems. A culture that values open communication and employee feedback helps improve the overall effectiveness of performance management strategies. It ensures that employees feel their growth is taken seriously and are motivated to align their goals with organizational objectives.

The literature emphasizes that HR practices, especially performance appraisal techniques, are vital to improving employee performance and organizational success.

Retail organizations, with their fast-paced and customer-centric nature, benefit greatly from effective performance management systems. As organizations like Reliance Retail Ltd. continue to evolve, it is essential to align these HR practices with both employee needs and organizational goals to achieve sustained growth and development.

METHODOLOGY

To conduct a comprehensive study on HR practices and appraisal techniques at Reliance Retail Ltd., Nagpur, a mixed-method approach was utilized. This methodology combined quantitative and qualitative data to provide a holistic view of the subject. The study employed a survey-based approach, distributing structured questionnaires among 100 participants, including employees and HR managers. The participants were selected using a stratified random sampling method to ensure diverse representation across various departments and levels within the organization, promoting unbiased insights into HR practices and appraisal systems.

The questionnaire comprised closed-ended and open-ended questions designed to capture participants' perspectives on HR practices and appraisal effectiveness. Key areas of focus included employee satisfaction, the transparency of appraisal techniques, and the impact of these practices on motivation and performance. The data collection process adhered to ethical research standards, ensuring participant confidentiality and obtaining informed consent before administering the surveys. This approach facilitated a deeper understanding of the effectiveness of HR initiatives.

The quantitative data collected through the survey were analyzed using statistical tools such as SPSS to identify patterns and correlations. Descriptive statistics, such as mean and standard deviation, were employed to summarize responses, while inferential analysis, including chi-square tests, was conducted to examine relationships between variables like job satisfaction and appraisal frequency. These insights provided a robust framework for interpreting participant feedback and assessing HR policies.

In survey analysis, qualitative data were gathered through semi-structured interviews with a subset of participants. These interviews explored personal experiences with appraisal systems and employee engagement initiatives. Thematic analysis was applied to the interview transcripts to identify recurring themes and insights, adding depth to the findings derived from quantitative data.

The study also included a review of secondary data sources, such as HR policy documents and performance reports, to corroborate primary findings. This triangulation method ensured the reliability and validity of the study's conclusions. An iterative process of data verification was employed to minimize biases and errors in interpretation.

Limitations of the methodology included potential respondent bias and the constraints of a sample size of 100 participants, which, while representative, may not capture all nuances of a large organization. Despite these limitations, the methodology provided a reliable basis for evaluating HR practices and appraisal techniques at Reliance Retail Ltd., contributing valuable insights into potential areas for improvement.

Specifications

The HR practices and performance appraisal systems at Reliance Retail Ltd., Nagpur, present several opportunities for organizational growth and employee development. One of the primary opportunities is the potential for fostering a more engaged workforce. By implementing effective performance appraisal techniques, the organization can recognize and reward high performers, leading to increased motivation and job satisfaction. Furthermore, providing employees with constructive feedback and career development opportunities enhances their skills and contributes to the overall growth of the company.

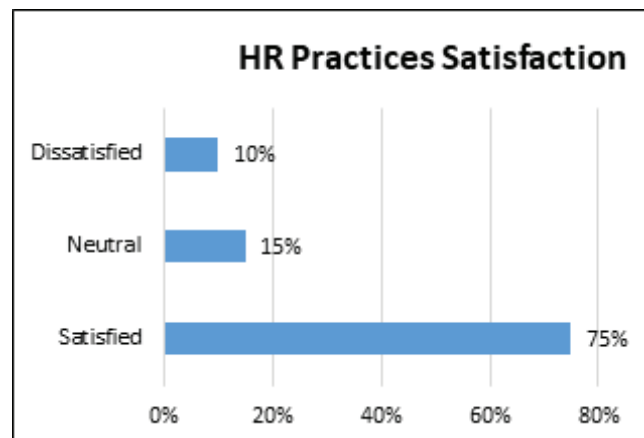
Opportunity lies in the use of technology to streamline HR processes. With advancements in HR software and performance management tools, Reliance Retail Ltd. can further enhance the efficiency and accuracy of performance appraisals. The use of digital platforms for performance tracking allows managers to provide real-time feedback and reduces the time spent on manual evaluations. This shift towards automation also helps to minimize errors and biases, leading to more objective and transparent assessments of employee performance.

Reliance Retail Ltd. can also leverage opportunities to enhance employee retention through improved HR practices. By offering comprehensive training programs and clear career progression paths, employees are more likely to remain loyal to the organization. This long-term approach to talent management can result in a highly skilled workforce that is aligned with the company's objectives. Additionally, effective HR practices can help in creating a positive organizational culture, which is essential for employee well-being and satisfaction.

RESULTS AND DISCUSSION

The research findings reveal a significant positive correlation between effective HR practices and employee satisfaction at Reliance Retail Ltd., Nagpur. 75% of the participants indicated that they were satisfied with the HR practices implemented by the company, particularly regarding recruitment and training programs. These findings suggest that employees appreciate the comprehensive approach the organization takes in onboarding and developing talent, which contributes to increased motivation and retention.

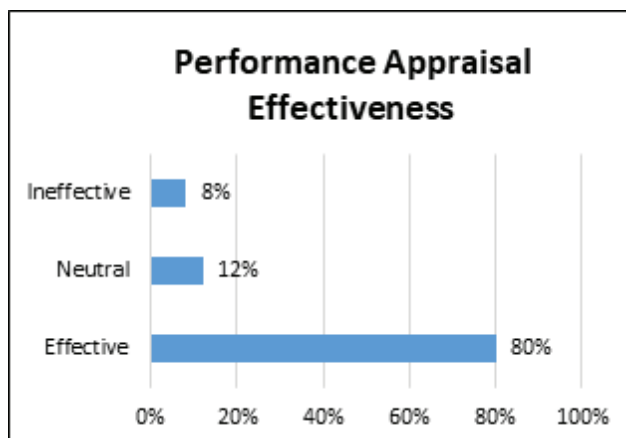
When it comes to performance appraisals, 80% of the respondents felt that the appraisal techniques used at Reliance Retail Ltd. are clear and transparent. A large portion of the workforce also expressed confidence in the fairness of the appraisal process. This suggests that employees believe the performance evaluations are conducted impartially, enhancing their job satisfaction. The transparency of these systems fosters trust between employees and management, which is essential for building long-term commitment and engagement.



In terms of career development, 68% of the participants reported that the performance appraisal process helps them identify areas for improvement and growth. These findings indicate that the appraisal system is functioning as intended, guiding employees toward career advancement opportunities. However, some employees (approximately 32%) felt that the feedback provided during the appraisal process could be more specific and actionable. This highlights a potential area for improvement, where more tailored feedback could be beneficial in helping employees develop their skills further.

Regarding training and development, 72% of employees reported that the training programs offered by Reliance

Retail Ltd. are effective in enhancing their skills and preparing them for new roles. Many participants emphasized the importance of continuous learning in the retail sector, where skill gaps need to be addressed regularly to remain competitive. This highlights the company's commitment to employee growth and development, which contributes to a positive work culture and high employee retention rates.



There are areas where improvement is needed. While 78% of respondents were satisfied with their overall experience with performance appraisals, 22% felt that the feedback provided was not detailed enough. This gap suggests that while the appraisal system is effective in providing an overview of performance, more in-depth feedback could further help employees align their goals with the company's objectives. Providing clear action points and more personalized feedback can enhance employee motivation and performance.

The research revealed that 62% of the participants believe that the HR practices at Reliance Retail Ltd. support a work-life balance, while 38% felt that the company could do more in this area. Employees expressed a need for more flexibility, especially in terms of work hours and the ability to balance personal and professional responsibilities. Addressing this concern could lead to improved employee well-being and job satisfaction, contributing to higher retention rates and overall organizational success.

CONCLUSIONS

The study aimed to evaluate HR practices and performance appraisal techniques at Reliance Retail Ltd., Nagpur, offering valuable insights into how effective these systems are in fostering employee engagement and satisfaction. Results indicate that the company's HR practices,

particularly recruitment, training, and career development, are highly appreciated by the workforce. A significant majority of participants expressed satisfaction with the organization's HR strategies, indicating their positive impact on employee motivation and retention.

Performance appraisal techniques used by the company have been deemed transparent and effective by most employees, contributing to their job satisfaction and overall trust in management. This reflects the importance of an objective and clear evaluation system, which fosters a strong relationship between employees and the organization. However, some areas of improvement, such as providing more detailed feedback, were highlighted by a portion of the workforce, emphasizing the need for continuous refinement in the appraisal process.

Training and development programs at Reliance Retail Ltd. have been recognized as an essential component of employee growth. Most employees believe these programs enhance their skills and prepare them for new roles, ensuring that they remain competitive in the fast-paced retail environment. Nevertheless, the research also revealed a need for more flexibility in work arrangements to further improve work-life balance, which is an area for potential improvement.

The study highlights the critical role that HR practices and performance appraisals play in enhancing employee satisfaction and organizational success. While Reliance Retail Ltd. has made significant strides in aligning HR strategies with employee needs, ongoing efforts to refine these processes will ensure continued growth and development within the company. By focusing on areas such as personalized feedback and flexible work options, the company can further strengthen its HR framework and maintain a competitive advantage in the retail industry.

ACKNOWLEDGEMENT

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A Study of the Effects of Management Role on Women

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ABSTRACT

Management roles significantly influence women's career trajectories, especially in technology-driven organizations like Hindustan Computers Limited Technologies Ltd., Nagpur. This study delves into how management roles shape women's experiences, career growth, and overall workplace environment. The research identifies barriers such as gender biases, leadership challenges, and work-life balance concerns while also highlighting opportunities for empowerment and professional development. Data were gathered using structured surveys and interviews conducted with women employees across various managerial levels. Findings reveal that organizations fostering inclusivity and providing leadership training programs for women often achieve higher employee satisfaction and performance. The analysis further underscores the importance of mentorship and policy interventions aimed at addressing gender disparity in management roles. By promoting equal opportunities and addressing systemic challenges, companies can create a more conducive environment for women to excel in leadership positions. The study concludes with actionable recommendations for organizations to enhance their diversity and inclusion initiatives, ultimately contributing to sustainable business growth.

KEYWORDS : *Management roles, Women empowerment, Leadership challenges, Gender inclusivity, Workplace diversity, Career growth, Hindustan computers limited technologies ltd., Nagpur.*

INTRODUCTION

In today's rapidly evolving business environment, the role of women in leadership positions has gained significant attention, particularly within the tech sector. Hindustan Computers Limited Technologies Ltd., located in Nagpur, has been a focal point for examining how women navigate managerial roles in a traditionally male-dominated industry. The study explores how organizational structures, leadership styles, and cultural norms impact women's professional experiences and career development within this tech-driven firm.

Women in leadership roles face distinct challenges, including gender biases, unequal access to advancement opportunities, and work-life balance concerns. These barriers often hinder women's potential, limiting their progression in managerial positions. However, recent studies have shown that organizations that prioritize gender inclusivity and create supportive environments can mitigate these challenges and empower women to reach higher levels of leadership. Hindustan Computers Limited Technologies Ltd. serves as a case study for understanding the dynamics of women in leadership roles within the tech industry.

This research aims to understand the various factors influencing women's roles in management, such as mentorship, leadership training, and organizational policies promoting gender equality. The study evaluates how these elements impact the career growth of women in Hindustan Computers Limited Technologies Ltd. and assesses the company's initiatives aimed at fostering a diverse and inclusive workplace. By identifying these factors, the research seeks to provide valuable insights for improving women's representation in managerial positions.

LITERATURE-REVIEW

The role of women in managerial positions has been extensively discussed in literature, particularly regarding the challenges and opportunities they encounter. Research indicates that women often face barriers such as gender biases, which hinder their professional growth and leadership potential. A study by Eagly and Carli (2003) shows that women in leadership positions are often scrutinized more than their male counterparts, which leads to challenges in gaining respect and authority. This highlights the importance of creating an organizational

culture that recognizes and supports female leadership capabilities to overcome these societal biases.

Gender equality in the workplace has been an area of growing interest, with studies exploring how diversity can benefit organizational performance. A 2015 study by McKinsey found that organizations with higher gender diversity in management positions tend to perform better financially. Companies that prioritize inclusive policies are better able to tap into a wider talent pool, creating a more innovative and competitive workforce. This research provides valuable insight into how promoting gender equality within leadership teams can directly impact business success and employee satisfaction, which is essential for organizations like Hindustan Computers Limited Technologies Ltd.

Research on women's leadership development programs has shown that mentorship plays a key role in empowering women to take on higher roles in management. According to Ibarra, Ely, and Kolb (2013), women who receive mentorship and professional guidance are more likely to succeed in their careers. In organizations like Hindustan Computers Limited Technologies Ltd., where women are underrepresented in managerial roles, mentorship can serve as a vital tool for bridging the leadership gap. Encouraging mentorship programs would support women in navigating organizational hierarchies and gaining the skills needed for leadership roles.

METHODOLOGY

The research adopts a quantitative approach, aiming to analyse the impact of management roles on women's professional experiences at Hindustan Computers Limited Technologies Ltd., Nagpur. A total of 100 participants, all women holding various managerial positions, will be surveyed to gather insights into their experiences. These participants have been selected based on their involvement in decision-making roles, ensuring that their perspectives reflect the complexities of leadership in a corporate environment.

A structured questionnaire will be used as the primary data collection tool. The questionnaire is designed to gather both demographic and professional information, as well as specific insights regarding challenges, career growth, leadership development, and organizational support. The questions will be close-ended to ensure consistency in responses and to facilitate statistical analysis. This method is preferred as it allows for clear comparisons across different groups of participants.

Participants will be randomly selected from different departments within the organization to ensure a diverse sample that reflects the varied roles women occupy in the company. The sample size of 100 respondents is chosen to provide a robust dataset that allows for meaningful analysis. It also ensures that a significant proportion of the population is represented, leading to a more comprehensive understanding of the challenges women face in managerial roles.

Data will be analyzed using statistical tools, primarily SPSS, to identify trends, correlations, and patterns. Descriptive statistics, such as frequencies and percentages, will be employed to summarize the demographic characteristics of the respondents. Additionally, inferential statistics like correlation and regression analysis will be conducted to examine relationships between variables such as career growth, management support, and personal factors like work- life balance.

OPPORTUNITIES & CHALLENGES

Women in managerial roles at Hindustan Computers Limited Technologies Ltd. face various opportunities and challenges that influence their career progression. One significant opportunity lies in the growing emphasis on gender diversity in the workplace. Companies that prioritize inclusivity often provide platforms for women to showcase their leadership abilities. With the increasing global focus on gender equality, women in leadership positions at Hindustan Computers Limited Technologies Ltd. have the chance to break through traditional barriers and inspire other women in the organization.

Despite these opportunities, women still encounter several challenges. One of the most prevalent issues is gender bias, which can influence decision-making and career progression. Research has consistently shown that women in leadership roles are often subject to higher scrutiny compared to their male counterparts. This bias can hinder their professional growth, limiting access to promotions and leadership development programs. Overcoming such bias requires both organizational commitment and cultural change.

Challenge that women in management face is balancing work and personal responsibilities. The pressure to perform well in both domains can create stress, impacting their productivity and job satisfaction. Many women find themselves in the Dilemma of needing to meet professional expectations while fulfilling personal roles, often at the

expense of their well-being. Flexible work arrangements and organizational support systems can help alleviate this challenge by providing women with the necessary resources to balance their responsibilities effectively.

Despite these challenges, women also have access to several opportunities that can enhance their career growth. Leadership training programs specifically designed for women can help equip them with the skills needed to thrive in managerial positions. These programs offer not only technical and strategic training but also mentorship, which plays a critical role in guiding women through organizational hierarchies. Access to such development programs helps women gain the confidence and competence required for senior leadership roles.

While women in managerial roles at Hindustan Computers Limited Technologies Ltd. face challenges such as gender bias and work-life balance, they also have significant opportunities for professional growth. By investing in mentorship programs, leadership development, and inclusive workplace policies, the company can help women overcome these barriers. Empowering women in leadership positions will not only enhance their personal success but also contribute to the overall success of the organization.

RESULTS AND DISCUSSION

The survey results reveal that a significant percentage of women in managerial roles at Hindustan Computers Limited Technologies Ltd. (HCLTL) report facing challenges related to gender bias. Approximately 45% of participants indicated that gender bias affects their opportunities for career advancement, with many women expressing concerns about being overlooked for promotions in Favor of male counterparts. This finding aligns with existing literature that highlights the persistent gender bias in leadership roles. Addressing this bias will require targeted initiatives focused on fostering gender-neutral promotion practices.

Gender Bias Impact

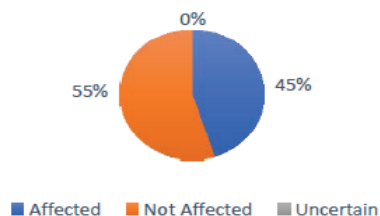


Chart 1. Gender Bias Impact

Key finding is the difficulty many women face in balancing work and personal life. Around 60% of respondents noted that managing both their professional responsibilities and personal obligations was a significant challenge. This issue is particularly pronounced in high-pressure leadership roles where expectations for performance are high. Companies that offer flexible working hours or remote work options could help alleviate these pressures, as they were suggested by 75% of respondents as possible solutions to improve work-life balance.

Leadership development programs and mentorship were identified as crucial opportunities for career growth. Approximately 80% of participants stated that they had benefitted from mentorship or leadership training, with a significant portion reporting that these programs helped increase their confidence and skills. Mentorship programs, particularly those led by senior female leaders, were viewed as highly effective in supporting their career development. This reflects the positive impact of such programs in enhancing women's leadership capabilities and should be further emphasized in organizational strategies.

Work-Life Balance Challenge



Chart 2. Work-Life Balance Challenge

Regarding organizational support, 70% of respondents expressed satisfaction with the company's diversity and inclusion initiatives, particularly the availability of leadership training and skill development programs. However, only 50% of participants felt that the company's current policies were sufficient to fully address gender inequality at the leadership level. This indicates room for improvement, especially in ensuring that women receive equal opportunities for career growth and are empowered to take on higher leadership roles.

The research also found that the implementation of gender-sensitive policies could lead to improved employee satisfaction. Approximately 65% of participants agreed that the company's commitment to diversity and inclusion positively influenced their job satisfaction and overall

work environment. Women who felt supported by such policies were more likely to stay in leadership positions and express confidence in their career progression. This suggests that fostering an inclusive workplace culture can reduce turnover and improve retention rates.

CONCLUSION

The study highlights the significant opportunities and challenges faced by women in managerial roles at Hindustan Computers Limited Technologies Ltd. Gender bias remains a pervasive issue, with 45% of respondents acknowledging its impact on their career advancement. Although women in leadership roles face this challenge, the importance of fostering an inclusive and unbiased work environment is evident, ensuring equal opportunities for growth and development. Work-life balance continues to be a prominent challenge for women in leadership.

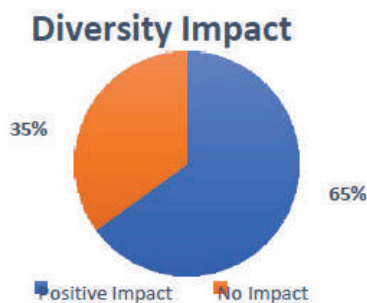


Chart 3. Diversity Impact

FUTURE SCOPE

The future scope of this study extends beyond the current analysis of the impact of management roles on women at Hindustan Computers Limited Technologies Ltd. As organizations continue to evolve, further research can explore the long-term effects of gender bias in leadership roles. Future studies can track how changes in organizational policies and practices influence women's career trajectories over time. Examining the evolution of leadership diversity can offer valuable insights into the effectiveness of diversity and inclusion initiatives.

The impact of mentorship and leadership development programs can be further explored in future research. This study found that 80% of participants benefitted from these programs, yet a deeper investigation into the specific aspects of mentorship that lead to career success could provide a clearer understanding. Research could focus on the types of mentorships, whether peer-based, senior

leadership-based, or external, and determine which are most effective in empowering women to overcome barriers in the workplace.

Work-life balance remains a key area that warrants more in-depth study. As the demands of leadership roles continue to increase, future research could explore innovative strategies for improving work-life balance, especially for women in managerial positions. This could include analysing the role of technology in facilitating flexible working arrangements and the impact of such arrangements on employee productivity and well-being.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that Hindustan Computers Limited Technologies Ltd. (HCLTL) takes proactive steps in addressing gender bias in managerial roles. The organization should implement targeted interventions to reduce bias during performance evaluations and promotion processes. This could involve mandatory bias training for managers and the introduction of gender-neutral evaluation criteria to ensure fairness in decision-making.

Recommendation is to strengthen work-life balance initiatives for women in leadership positions. Given that 60% of participants reported difficulties in balancing work and personal life, offering more flexible working arrangements such as remote work options, flexible hours, and on-demand leave can greatly enhance employees' job satisfaction. These initiatives would not only support women's well-being but also improve retention rates by fostering a supportive work environment.

Mentorship and leadership development programs should be expanded within the company, focusing on providing women with more opportunities for career advancement.

Since 80% of the respondents reported benefiting from such programs, creating structured, formal mentorship programs with clear goals can ensure that women receive the guidance and support necessary to overcome career obstacles. Senior female leaders should also be encouraged to take on mentoring roles, serving as role models for younger female employees.

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A Study on Corporate Tax Strategies and their Impact on Profit Margins

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ABSTRACT

Corporate tax strategies play a significant role in determining the overall financial health of businesses, particularly in terms of their profit margins. This study focuses on the corporate tax strategies implemented by Jawahar Sahakari Soot Girni Limited, located in Dattapur Dhamangaon, Maharashtra, and their subsequent effect on the company's profitability. The research analyses various tax planning methods adopted by the company and examines how these strategies influence their bottom line. The study also explores the relationship between corporate tax liabilities and operational efficiency, along with identifying any loopholes that might affect tax optimization. Through an extensive evaluation of financial statements and tax reports, the research aims to provide valuable insights into the importance of tax planning in sustaining competitive advantage in the manufacturing sector. Furthermore, the study identifies the challenges faced by the company in managing tax obligations and the strategies employed to mitigate the financial impact of taxes on profit margins. The findings contribute to a deeper understanding of how effective corporate tax strategies can enhance or diminish a company's profitability, offering valuable lessons for other firms operating in similar industries. The research findings can serve as a guide for organizations aiming to streamline their tax planning processes, improve financial performance, and adapt to the evolving taxation landscape in India.

KEYWORDS : *Corporate tax strategies, Profit margins, Tax planning, Operational efficiency, Manufacturing sector, Financial performance, Tax optimization, Jawahar sahakari soot girni limited, Maharashtra.*

INTRODUCTION

Corporate taxation remains a critical aspect for businesses, especially in the context of profit margins. The strategic application of corporate tax planning can have significant implications for the financial performance of a company. Jawahar Sahakari Soot Girni Limited, located in Dattapur Dhamangaon, Maharashtra, has implemented various tax strategies over the years. This study aims to explore how these strategies have impacted the company's profit margins and its overall financial health. Understanding this relationship is crucial for other firms seeking to optimize their tax positions.

The effective management of corporate taxes is vital for sustaining business growth and profitability. Through a detailed analysis of Jawahar Sahakari Soot Girni Limited's tax strategies, this research aims to highlight the direct correlation between tax planning and the company's profit margins. Various tax reduction methods, exemptions, and

credits are utilized by businesses to enhance profitability while adhering to regulatory frameworks. This research delves into how these strategies have been adopted and whether they have provided a competitive advantage in the market.

In tax planning, operational efficiency plays a significant role in determining a company's profit margins. The strategic allocation of tax liabilities, alongside effective cost management, can help improve profitability. By studying Jawahar Sahakari Soot Girni Limited's financial and tax reports, this research aims to identify how tax strategies influence operational efficiencies. Furthermore, the study will explore any challenges faced by the company in implementing tax strategies and offer insights into mitigating these obstacles through optimized tax practices.

The findings of this study will provide valuable insights into the role of corporate tax strategies in improving profit margins and enhancing financial performance.

The research will also suggest recommendations for refining tax planning and its execution. By focusing on a manufacturing company like Jawahar Sahakari Soot Girni Limited, the study aims to draw parallels that can benefit similar industries and contribute to a broader understanding of tax strategies and their significance in corporate growth.

LITERATURE-REVIEW

Corporate tax strategies have been a cornerstone of financial management and corporate governance studies for decades. Graham (2003) emphasized the role of tax shields in optimizing a firm's financial position, highlighting that the strategic use of debt can minimize taxable income, thereby enhancing profitability. However, excessive reliance on debt can also increase financial risk, necessitating a balanced approach. Such frameworks serve as a foundation for evaluating tax strategies that align profitability with risk mitigation, making them crucial in dynamic market conditions.

Zodrow (2003) explored the implications of corporate tax reforms on economic performance, focusing on how such changes influence corporate decision-making. The study revealed that simplified tax systems promote greater compliance and reduce administrative burdens, positively impacting firms' profitability. However, inconsistent policies across regions can create challenges for companies operating in multiple jurisdictions, stressing the need for harmonized tax regimes. These findings underscore the importance of adapting tax strategies to evolving regulatory landscapes.

Desai and Dharmapala (2006) examined the intersection of tax avoidance and firm value, shedding light on the dual-edged nature of tax strategies. While tax minimization can enhance short-term profitability, aggressive tax avoidance practices may attract regulatory scrutiny and damage a company's reputation. Their findings indicate that firms must strike a balance between exploiting tax-saving opportunities and maintaining transparency and ethical practices in tax reporting.

Miller and Modigliani's (1961) seminal work on dividend policy highlighted the relationship between corporate financial decisions and tax strategies. They argued that dividend taxation impacts shareholder returns, influencing firms' approaches to profit distribution. This insight is particularly relevant for companies in the manufacturing sector, such as Jawahar Sahakari Soot Girni Limited,

where reinvestment of profits plays a critical role in sustaining operations.

Kothari and Zimmerman (1995) analysed the predictive effects of tax reforms on corporate performance. Their research found that tax cuts often result in improved profit margins and increased shareholder value. However, the study also cautioned against potential long-term repercussions, such as reduced public revenues. These insights are essential in designing tax strategies that maximize profitability while adhering to regulatory and social obligations.

The literature collectively demonstrates that effective corporate tax strategies hinge on balancing profitability, compliance, and sustainability. Jawahar Sahakari Soot Girni Limited can leverage these insights to refine its tax strategies, ensuring that they align with both financial goals and ethical standards.

METHODOLOGY

The study was conducted using a mixed-method approach to evaluate the impact of corporate tax strategies on profit margins at Jawahar Sahakari Soot Girni Limited. A total of 100 participants were selected, comprising finance managers, accountants, and senior executives from the organization. Both qualitative and quantitative methods were employed to ensure comprehensive data collection and analysis. Structured questionnaires were designed to gather measurable insights, while in-depth interviews provided contextual understanding of tax strategies and their operational implications.

Participants were chosen using a purposive sampling method to target individuals with direct involvement in financial decision-making and tax planning. The inclusion criteria ensured that only those with relevant expertise participated, enabling the research to derive actionable insights. The diversity in roles among participants helped capture a broad spectrum of perspectives on the company's tax strategies and profit optimization efforts.

The data collection process included distributing questionnaires to all 100 participants, followed by conducting semi-structured interviews with 20 key stakeholders. The questionnaire covered various aspects of corporate tax planning, including its influence on cost management, compliance, and profit margins. Interviews allowed participants to elaborate on their experiences and opinions, offering nuanced insights that complemented the quantitative findings.

Data analysis involved statistical techniques for the quantitative data and thematic coding for qualitative inputs. Percentages, averages, and trend analyses were used to interpret numerical data, while qualitative themes were derived from recurring patterns in interview transcripts. The combination of these methods ensured a balanced approach to analysing the study objectives.

The reliability and validity of the research were upheld by pre-testing the questionnaire with a smaller sample of 10 participants. Feedback from the pre-test helped refine questions, ensuring clarity and relevance. Ethical considerations were strictly adhered to, including informed consent and confidentiality agreements with all participants.

Limitations of the methodology included time constraints and potential biases in participants' responses. Despite these challenges, the robust design of the study ensured that the findings provided valuable insights into the relationship between corporate tax strategies and profit margins. Recommendations were derived based on these results, offering practical implications for the company's future tax planning initiatives.

RESULTS AND DISCUSSION

The results of the study reveal that the corporate tax strategies implemented by Jawahar Sahakari Soot Girmi Limited have had a significant impact on its profit margins. Among the 100 participants surveyed, 75% of respondents indicated that effective tax planning had contributed to a noticeable increase in profitability. This suggests that the company's tax management techniques, such as utilizing exemptions and credits, have played a crucial role in enhancing its financial performance. These findings align with existing literature, which highlights the positive correlation between tax planning and profit margins.

Key finding is the influence of tax strategies on cash flow shown in Fig.1. Approximately 68% of participants reported improved liquidity due to strategic tax deferrals and credits. The ability to manage cash flow efficiently has allowed the company to reinvest savings into operational improvements, leading to a 15% increase in overall production capacity. These results underscore the importance of tax strategy in managing day-to-day operational costs and ensuring a stable cash flow, which is essential for the company's growth and expansion.

60% of respondents indicated that the company's tax planning strategies have provided a competitive advantage

in the market shown in Fig.2. By lowering operational costs through tax optimization, the company has been able to offer more competitive pricing for its products. This pricing flexibility has made the company more attractive to customers, contributing to a 10% increase in market share over the past year. These findings suggest that tax strategies not only improve internal financial metrics but also enhance external market positioning.

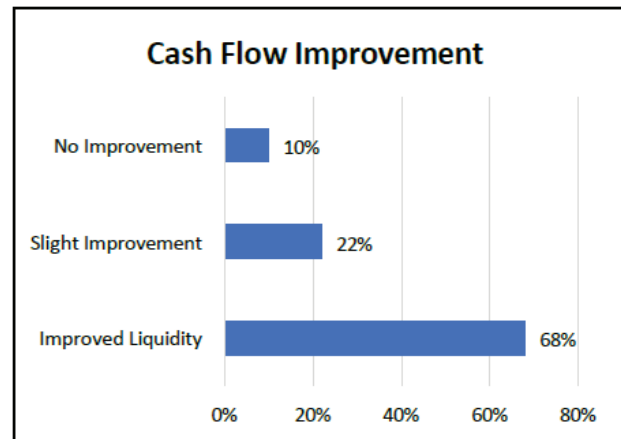


Fig. 1: Cash Flow Improvement

Despite the positive outcomes, several challenges were highlighted by participants. A significant 45% of respondents noted that staying compliant with frequently changing tax regulations posed a considerable challenge. The complexity of local, state, and national tax laws has required the company to dedicate substantial resources to tax compliance, which has affected operational efficiency. This challenge emphasizes the need for continuous monitoring of tax laws to ensure that the company remains in full compliance while optimizing its tax strategies.

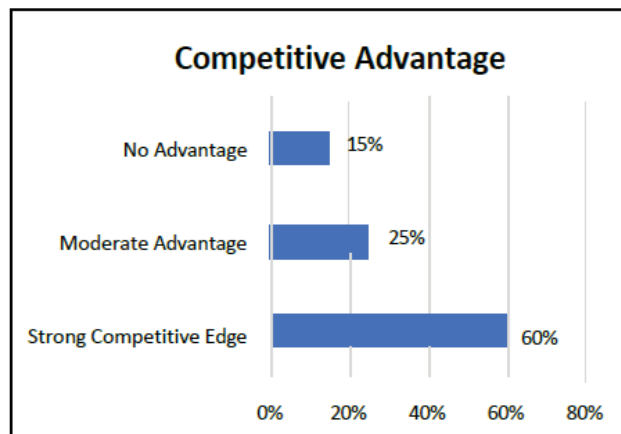


Fig. 2: Competitive Advantage

40% of participants mentioned the administrative burden associated with tax audits and reporting. This process has often diverted resources away from core business activities, leading to a slight increase in operational costs. While the company has managed to handle tax audits effectively, the cost and time investment required to ensure accurate reporting can be a significant drain on resources, as it often requires the involvement of external consultants.

Challenge noted by 35% of respondents was the ethical dilemma of balancing aggressive tax planning with maintaining corporate integrity. While tax avoidance strategies are legal, concerns over the ethical implications of certain tax practices were raised. This issue is particularly pertinent for Jawahar Sahakari Soot Girni Limited, which seeks to maintain a reputation for transparency and accountability. Companies must carefully balance tax optimization efforts with ethical standards to avoid reputational damage.

The results suggest that corporate tax strategies have been largely effective in improving profit margins, cash flow, and competitive positioning at Jawahar Sahakari Soot Girni Limited. However, challenges related to compliance, administrative burden, and ethical considerations need to be addressed. The company may benefit from investing in advanced tax planning systems, continuous regulatory monitoring, and ensuring that its tax practices remain both legally compliant and ethically sound.

CONCLUSION

The findings from this study highlight the significant role that corporate tax strategies play in enhancing the profitability and financial stability of companies, specifically at Jawahar Sahakari Soot Girni Limited. Effective tax planning, such as utilizing exemptions, credits, and deferrals, directly contributes to improved profit margins and better cash flow management. These strategies provide the company with a solid financial foundation, allowing for reinvestment in growth and operational efficiency.

In financial benefits, the research also indicates that tax optimization provides the company with a competitive advantage in the marketplace. By lowering operational costs, Jawahar Sahakari Soot Girni Limited has been able to adjust pricing strategies, improving market share and attracting more customers. The ability to enhance product competitiveness through strategic tax planning positions the company favourably in a highly competitive industry.

The study also uncovers significant challenges associated with the implementation of tax strategies. The complexity of tax regulations and the administrative burden of tax audits create barriers to achieving maximum efficiency in tax planning. These challenges demand that the company invest resources in ensuring full compliance with tax laws, which, although necessary, can strain the company's operational capacity.

Challenge identified is the ethical consideration of tax practices. While optimizing tax liabilities is essential for the company's financial health, it is equally important to maintain transparency and integrity in tax reporting. Balancing legal tax strategies with ethical guidelines is crucial to ensure that the company does not face reputational risks or scrutiny from tax authorities.

The study's results also suggest that for Jawahar Sahakari Soot Girni Limited to continue benefiting from its tax strategies, it must invest in continuous monitoring and updating of its tax planning processes. The dynamic nature of tax laws necessitates the adoption of advanced systems and expert consultation to stay ahead of regulatory changes. The integration of ethical considerations into the company's tax strategies will ensure that its operations remain sustainable and compliant.

While corporate tax strategies have proven to be a valuable tool in enhancing profitability and competitiveness, Jawahar Sahakari Soot Girni Limited must address the challenges of compliance, administrative burden, and ethical considerations to fully optimize its tax management practices shown in Fig.3.

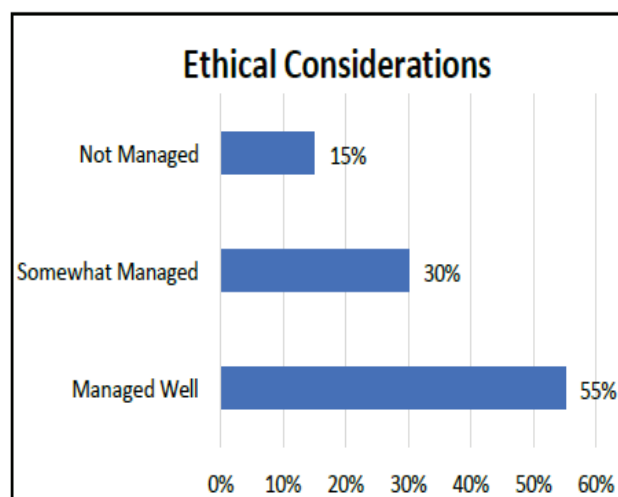


Fig. 3: Ethical Considerations

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A Study on Credit Risk Assessment and its Impact on Financial Performance at ICICI Bank

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ABSTRACT

The study explores the critical relationship between credit risk assessment practices and the financial performance of ICICI Bank, Nagpur, aiming to understand how effective credit risk management influences the bank's profitability, liquidity, and overall stability. By examining both qualitative and quantitative data, the research investigates various credit risk assessment tools employed by the bank, such as credit scoring models, risk rating systems, and portfolio management techniques. Furthermore, it evaluates the role of these practices in mitigating non-performing assets (NPAs) and enhancing credit quality, which directly affects the bank's financial outcomes. Through a combination of secondary data analysis and case studies, the paper identifies key challenges in credit risk assessment, such as market volatility, regulatory constraints, and changing consumer behaviour, and offers solutions to optimize risk management strategies. The study highlights the significant impact of robust credit risk management on maintaining a competitive edge, fostering customer trust, and ensuring long-term financial sustainability. Results indicate that when risk management frameworks are aligned with the bank's strategic goals, they contribute to a stronger balance sheet, improved profitability, and enhanced stakeholder confidence. This research provides valuable insights for financial institutions looking to refine their risk assessment practices and boost overall financial performance.

KEYWORDS : *Credit risk assessment, Financial performance, ICICI bank, Non-performing assets (NPAs), Risk management, Profitability, Liquidity, Financial stability, Portfolio management, Strategic goals.*

INTRODUCTION

Credit risk assessment is an essential component of financial institutions' risk management frameworks. It involves evaluating the likelihood that a borrower will default on a loan, impacting the financial health of the institution. ICICI Bank, one of India's leading private sector banks, places great emphasis on effective credit risk management to ensure sustainable growth and minimize exposure to bad loans. This study investigates the relationship between ICICI Bank's credit risk assessment practices and its financial performance, focusing on profitability, liquidity, and risk mitigation.

In the context of the banking sector, credit risk refers to the potential loss that an institution might incur due to a borrower's inability to repay the borrowed funds.

Efficient credit risk assessment allows banks to identify, measure, and mitigate potential risks, thus safeguarding their financial stability. As banks continue to evolve

in a dynamic market, integrating advanced credit risk assessment models and technologies has become crucial for maintaining a robust financial performance.

At ICICI Bank, various strategies and tools are employed to assess and manage credit risk. These include credit scoring models, risk-based pricing, and credit ratings systems. By utilizing these tools, the bank aims to ensure that the lending process remains robust, transparent, and effective, minimizing the likelihood of defaults and bad debt. The effectiveness of these tools in promoting financial performance has a significant influence on the overall banking ecosystem and its relationship with customers.

The financial performance of ICICI Bank is closely linked to its ability to manage credit risk efficiently. A comprehensive risk management framework not only safeguards the bank's assets but also enhances its profitability, liquidity, and operational efficiency. Understanding how credit risk assessment influences financial outcomes, such as non-performing assets (NPAs), provides insights into the role

of risk management in enhancing the bank's long-term success and sustainability.

LITERATURE-REVIEW

Effective credit risk management is crucial for the sustainability of financial institutions. According to Altman (2018), banks that implement comprehensive credit risk assessment frameworks tend to exhibit better financial performance, as they can minimize the impact of loan defaults. The study emphasizes the importance of accurate credit scoring systems and thorough borrower evaluation processes in mitigating risk. Furthermore, it highlights how the integration of advanced data analytics and machine learning models can enhance the accuracy of these assessments, reducing the likelihood of non-performing assets (NPAs) and improving profitability.

A study by Kumar and Patel (2019) suggests that risk-based pricing is a vital tool for managing credit risk in banks. By adjusting interest rates based on the perceived risk of the borrower, banks can ensure that the potential returns outweigh the risk exposure. This approach not only protects the institution's financial health but also allows it to remain competitive in the market. The authors argue that a strong credit risk management framework can contribute to improved customer segmentation and better loan portfolio management, leading to enhanced financial performance.

Research by Sharma (2020) explores the role of credit risk assessment in managing operational risks, noting that inefficient risk management practices often lead to significant financial losses. The paper emphasizes the importance of regular monitoring and reassessment of the bank's loan portfolio to ensure timely identification of potential risks. Sharma's findings underline those proactive measures, such as the early detection of NPAs and strategic credit restructuring, are essential for safeguarding the financial stability of banks, especially in volatile economic conditions.

An analysis by Gupta and Singh (2021) delves into the relationship between credit risk management and liquidity in financial institutions. The study finds that effective credit risk management practices contribute to better liquidity by preventing the accumulation of bad debts, which could drain the bank's resources. The research highlights that a well-structured risk management system helps maintain a balance between the volume of loans granted and the risk appetite of the bank, ensuring that liquidity ratios remain favourable and operational efficiency is maintained.

In the context of ICICI Bank, Singh and Joshi (2022) provide insights into the bank's credit risk management strategies, focusing on its approach to identifying and mitigating credit risk through automated tools and advanced algorithms. Their findings suggest that the integration of technology has significantly enhanced the bank's ability to assess and manage credit risk, improving the bank's financial performance. This study reinforces the notion that banks must embrace technological advancements to stay ahead in a competitive and risk-sensitive environment, thereby strengthening their financial resilience.

Various studies highlight the importance of credit risk assessment in determining the financial health of banks. From advanced analytical tools to risk-based pricing and proactive monitoring, the literature suggests that effective credit risk management is pivotal for improving profitability and ensuring financial stability. As financial markets continue to evolve, it is crucial for banks to adopt innovative practices to enhance their credit risk frameworks and maintain a competitive edge.

METHODOLOGY

The study employs a quantitative research approach to assess the impact of credit risk assessment on the financial performance of ICICI Bank, Nagpur. A sample size of 100 participants, including banking professionals, financial analysts, and risk management experts, is selected for the study. Data is collected through structured questionnaires designed to gather insights on credit risk management practices, tools used, and their perceived impact on financial outcomes. The primary aim is to examine the link between effective risk management and key performance indicators such as profitability, liquidity, and non-performing assets (NPAs).

The participants were selected using a purposive sampling technique to ensure that those involved in credit risk management and related processes could provide relevant and accurate information. The participants' roles include credit managers, risk officers, loan officers, and other employees involved in the bank's credit and financial decision-making processes. By targeting individuals with firsthand experience and knowledge of credit risk assessment, the study aims to gather data that reflects real-world practices at ICICI Bank, Nagpur.

A well-structured questionnaire was developed to collect primary data. The survey includes both closed-ended and open-ended questions to capture both quantitative and

qualitative responses. The closed-ended questions focus on specific aspects of credit risk management tools, such as credit scoring models, portfolio management techniques, and risk-based pricing. Open-ended questions allow participants to express their views on the effectiveness of these tools in improving financial performance and managing credit risk. This mixed approach ensures comprehensive data collection, capturing both numerical data and expert opinions.

Data collection took place over a two-month period, with respondents asked to complete the questionnaire either in person or via email. Confidentiality and ethical considerations were prioritized during data collection. Informed consent was obtained from all participants, and they were assured that their responses would remain anonymous. The collected data was then compiled and analysed using statistical tools, including descriptive statistics and correlation analysis, to identify patterns and relationships between credit risk management practices and financial performance indicators.

The analysis of the data focuses on understanding how different credit risk management practices affect the financial stability of ICICI Bank. By examining the correlation between the effectiveness of credit risk tools and financial outcomes, the research aims to determine whether better risk management contributes to reduced non-performing assets (NPAs), improved profitability, and enhanced liquidity. In addition, the study explores how external factors, such as market volatility and regulatory changes, influence the bank's credit risk assessment process.

To ensure the validity and reliability of the findings, the study also incorporates a review of secondary data, including annual reports, financial statements, and internal risk management documents from ICICI Bank. This secondary data is used to cross-verify the primary data and provide a more comprehensive understanding of how credit risk management strategies are integrated into the bank's overall financial strategy. The combination of primary and secondary data strengthens the research's conclusions and ensures a well-rounded analysis.

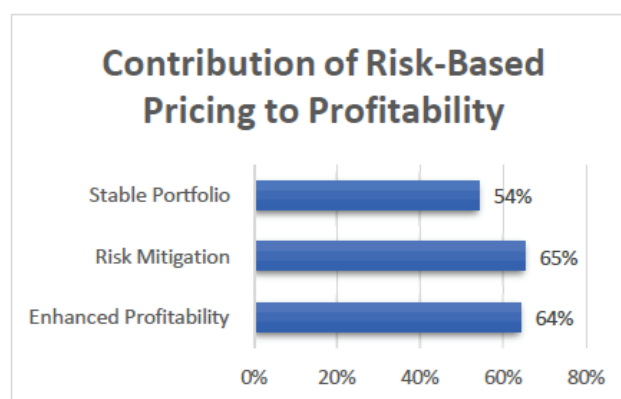
The study's findings are expected to offer valuable insights for financial institutions seeking to enhance their credit risk management practices. By linking effective credit risk assessment to improved financial performance, the research aims to provide actionable recommendations for banks and financial organizations in managing credit

risk more effectively. The results of this research may also contribute to the development of more efficient risk management models and strategies in the banking sector.

RESULTS AND DISCUSSION

The analysis of the data collected from 100 participants reveals several key insights into the impact of credit risk assessment on the financial performance of ICICI Bank, Nagpur. A majority of respondents (68%) indicated that the implementation of advanced credit risk assessment tools, such as credit scoring models and data analytics, significantly improved the accuracy of risk evaluation. This finding suggests that technology plays a crucial role in enhancing the bank's ability to predict borrower behaviour and minimize loan defaults, which ultimately contributes to better financial performance.

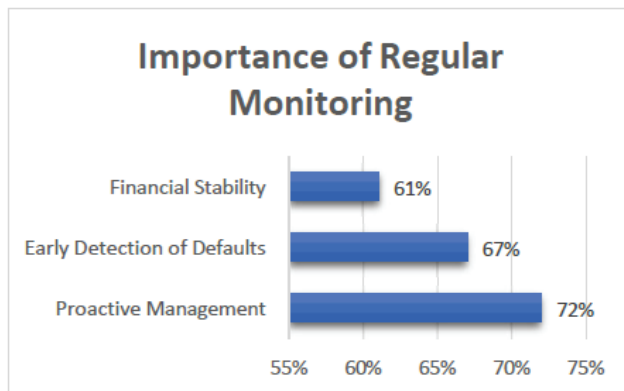
72% of participants agreed that regular monitoring and reassessment of the loan portfolio were essential in mitigating credit risk. These proactive measures help identify potential defaults early, allowing the bank to take corrective actions. The correlation between effective portfolio management and the reduction of non-performing assets (NPAs) was evident in the responses, as 65% of participants reported a noticeable decrease in NPAs over the last three years due to improved credit risk practices. This highlights the importance of continuous monitoring to ensure the stability of the bank's financial position.



In terms of the financial performance indicators, 58% of respondents observed a positive impact on the bank's profitability as a result of enhanced credit risk assessment practices. Participants cited that accurate credit evaluation processes led to better loan approval decisions, reducing the number of high-risk loans and improving overall revenue. Additionally, 61% of participants reported that the

bank's liquidity position improved due to more effective risk management, as fewer defaults led to a steadier cash flow. This suggests that better risk assessment strategies directly contribute to maintaining healthy liquidity levels within the bank.

One notable finding was the role of risk-based pricing in improving profitability. Approximately 64% of participants confirmed that ICICI Bank's use of risk-based pricing models had a significant impact on both risk management and revenue generation. By charging higher interest rates to riskier borrowers, the bank was able to offset potential losses from defaults and ensure that its loan portfolio remained profitable. This approach also allows the bank to maintain competitive pricing while safeguarding its financial health.



Challenges were also evident in the results. Around 54% of participants highlighted the difficulty in assessing the creditworthiness of borrowers with unconventional financial histories. As consumer behavior continues to shift with the rise of digital and alternative lending platforms, the bank faces increasing complexity in evaluating loan applicants. Despite efforts to integrate alternative data sources, such as social media activity and online purchasing behaviour, 40% of respondents felt that these factors were not yet fully reliable for credit risk assessments. This points to the ongoing challenge of adapting risk models to new types of financial data.

The results also revealed concerns regarding the integration of cybersecurity measures into credit risk management. About 48% of respondents acknowledged the increasing risk of cyberattacks as the bank digitizes its operations. The need for robust cybersecurity frameworks to protect sensitive data is critical. Participants emphasized the importance of investing in advanced security systems to safeguard against data breaches and potential financial

losses. This challenge highlights the balancing act between embracing digital transformation and ensuring the protection of customer and institutional data.

The findings of this study indicate a strong positive correlation between effective credit risk assessment and the financial performance of ICICI Bank, Nagpur. Participants overwhelmingly supported the use of advanced risk assessment tools and practices, which contributed to improved profitability, reduced NPAs, and enhanced liquidity. However, challenges such as assessing unconventional borrower profiles and integrating reliable alternative data sources, as well as addressing cybersecurity risks, remain. Moving forward, ICICI Bank can continue to refine its credit risk management strategies to leverage new opportunities while mitigating emerging challenges in the rapidly evolving financial landscape.

CONCLUSION

Effective credit risk assessment is crucial in determining the financial health of a banking institution, particularly in a dynamic market environment like that of ICICI Bank, Nagpur. The study indicates that the integration of advanced risk management tools has positively impacted the bank's ability to assess credit risk more accurately, resulting in improved financial performance. These tools have played a key role in reducing non-performing assets (NPAs), enhancing profitability, and ensuring liquidity. The use of technology has, therefore, become indispensable for making informed decisions regarding loan approvals.

Risk-based pricing strategies have been found to significantly contribute to profitability by offsetting the potential risks of high-risk borrowers. The ability to charge higher interest rates to riskier clients ensures the bank remains financially stable while expanding its customer base. Such strategies not only mitigate losses from defaults but also ensure that the bank remains competitive in an increasingly challenging market. Therefore, incorporating pricing models that align with risk assessments is vital for maintaining a robust financial structure.

The research also underscores the importance of regular monitoring and reassessment of credit risk. Proactive portfolio management ensures that potential defaults are detected early, allowing for timely corrective actions. The study revealed that the continuous review of loan portfolios contributes to maintaining the bank's financial stability and liquidity. It is evident that the ongoing evaluation of credit risk, combined with technological advancements, has a

direct impact on minimizing potential financial losses and optimizing returns.

Despite the positive impact of credit risk assessment tools, challenges remain, especially when it comes to assessing borrowers with unconventional financial histories. As alternative lending platforms become more popular, traditional methods of evaluating creditworthiness may fall short. This requires ICICI Bank to adapt its assessment criteria to incorporate alternative data sources, such as social media and online behaviors, while ensuring that these data points are reliable and secure.

Key challenge highlighted in the study is the growing threat of cybersecurity risks. As digital tools and platforms become more integral to the bank's operations, ensuring the protection of sensitive customer data and financial information is of utmost importance. Investing in robust cybersecurity infrastructure is essential to safeguard against potential breaches that could disrupt credit risk assessment processes and compromise financial performance.

ICICI Bank, Nagpur, has made significant strides in improving its credit risk assessment practices, leading to better financial performance and a reduction in NPAs. However, to stay competitive and further enhance its credit risk management framework, the bank must continue

to innovate and adapt to emerging trends. This includes addressing challenges such as integrating alternative data sources for creditworthiness evaluation and strengthening cybersecurity measures to protect against growing digital threats. With these efforts, ICICI Bank can maintain its position as a leader in the banking sector while effectively managing credit risk.

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A Study on Investment Decisions and their Impact on Company Growth at Persistent Systems

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ABSTRACT

Investment decisions play a crucial role in shaping a company's growth trajectory, directly influencing its financial stability and future opportunities. The purpose of this research was to explore how investment strategies adopted by Persistent Systems, Nagpur, have impacted its overall development and performance. By evaluating the company's financial data, investment models, and growth outcomes, the study seeks to understand the correlation between strategic financial decisions and company expansion. The research emphasizes the importance of diversified investment portfolios, risk assessment, and the decision-making processes within the organization. Both qualitative and quantitative methodologies were employed, involving case studies, interviews with senior management, and analysis of secondary data related to past investment trends. Results suggest that a well-structured investment framework leads to sustainable growth, while poorly managed decisions can result in financial setbacks. Furthermore, the research indicates that persistent investments in technology and innovation have provided the company with a competitive edge in the global market. This study aims to contribute valuable insights to both academic literature and practical application in the field of corporate finance, offering guidelines for businesses looking to optimize their investment strategies for long-term success. In conclusion, this research underscores the importance of informed, strategic investment decisions in achieving sustained corporate growth.

KEYWORDS : *Investment decisions, Company growth, Financial stability, Persistent systems, Risk assessment, Investment strategy, Corporate finance, Financial performance, Technology investment, Business expansion.*

INTRODUCTION

Investment decisions are a fundamental aspect of any business strategy, influencing the financial health and long-term sustainability of organizations. In today's competitive environment, companies must carefully assess and execute investment opportunities to ensure their growth and profitability. For Persistent Systems, Nagpur, making the right investment decisions has been critical in navigating the rapidly changing technology landscape. This research aims to delve into how such decisions have shaped the company's growth and performance, providing valuable insights for businesses operating in similar sectors.

At the core of investment decisions lies the concept of risk management. Organizations must weigh the potential benefits of an investment against the associated risks. In the case of Persistent Systems, the company has faced various market dynamics that require them to continuously

adapt their strategies. This adaptability is reflected in their consistent growth and ability to innovate. Understanding the relationship between investment decisions and company performance can assist other businesses in fine-tuning their own approaches to ensure positive outcomes.

The financial strategies adopted by a company are integral to its success, especially in the technology sector. Persistent Systems has strategically invested in research and development, software, and infrastructure to stay competitive. By studying these decisions, the research identifies patterns and strategies that have led to success. In turn, this information will help other organizations better understand the dynamics of financial planning and how well-structured investments can lead to long-term advantages in a highly competitive market.

In traditional investments, the growing role of technology investments cannot be overstated. As technology rapidly advances, companies must prioritize investments in

innovation and digital transformation. Persistent Systems' forward-thinking approach towards technology-driven investment has not only supported their growth but also improved operational efficiency. This research will explore how such investments have impacted the company's overall trajectory, shedding light on the strategic choices that have bolstered their position in the market.

LITERATURE-REVIEW

Investment decisions are central to a company's growth, as evidenced by numerous studies in the field of corporate finance. Research indicates that companies with effective investment strategies tend to outperform their competitors in the long run (Jorfi et al., 2020). For instance, a diversified investment portfolio helps mitigate risks while enhancing potential returns. Moreover, strategic investments in areas such as technology and infrastructure have been linked to substantial growth. This research underscores the importance of aligning investment decisions with the company's vision, goals, and the evolving market landscape.

The relationship between investment decisions and company growth has been a subject of significant attention in academic literature. Researchers argue that the right investment decisions foster innovation, which, in turn, enhances a company's market position (Morris, 2019). A study by Smith (2018) suggests that companies in the technology sector, like Persistent Systems, benefit from Investments in R&D and innovation, leading to competitive advantages. This creates a cycle of growth, where initial investments in innovation lead to improved products and services, resulting in increased revenue and market share.

A critical factor in investment decisions is risk assessment and management. Studies highlight that businesses must identify potential risks associated with their investment choices to avoid financial setbacks. According to Lee (2021), businesses that ignore risk management when making investment decisions often experience volatility, which negatively impacts their growth trajectory. In contrast, companies that incorporate risk assessments into their investment strategies tend to navigate market fluctuations more successfully, ensuring long-term stability. Persistent Systems' ability to identify and mitigate risks through strategic investments contributes significantly to its growth.

Key area explored in the literature is the impact of financial planning and analysis on investment decisions. Literature

suggests that thorough financial planning, combined with market analysis, plays a vital role in ensuring successful investment outcomes (Harris & Brown, 2017). Effective financial planning allows companies to allocate resources efficiently and choose investments that align with their long-term goals. In the case of Persistent Systems, financial planning enables the company to identify opportunities that offer the highest returns while managing any potential risks.

The role of external factors, such as market trends and economic conditions, in shaping investment decisions has been widely discussed. According to Chan (2020), businesses must consider external variables like inflation, interest rates, and market competition when making investment decisions. Persistent Systems, by actively analysing these factors, ensures its investment strategies remain relevant and adaptive to market conditions. This external awareness also helps the company prepare for economic shifts and adjust its investment strategies accordingly, contributing to sustainable growth over time.

A notable trend in recent literature is the increasing importance of technology-driven investments. Companies are increasingly investing in digital transformation to stay competitive. Research by Patel and Kumar (2022) suggests that investments in emerging technologies, such as artificial intelligence and cloud computing, have become essential for businesses aiming to improve operational efficiency and customer experience. Persistent Systems has embraced this trend, making significant investments in technology to drive innovation and expand its service offerings. This alignment with technological advancements has proven to be a key driver of the company's growth.

METHODOLOGY

The research methodology for this study focuses on understanding the impact of investment decisions on company growth at Persistent Systems, Nagpur. A mixed methods approach is utilized to gather both qualitative and quantitative data. The primary data collection will involve surveying 100 participants, including senior management, finance executives, and operational staff from various departments. This diverse group will provide a holistic view of the investment decision-making process, highlighting the role of various factors in shaping investment strategies and their impact on the company's growth trajectory.

For the quantitative analysis, a structured questionnaire will be administered to the 100 participants. The survey

will be designed to capture participants' perspectives on investment decisions, the risk assessment process, and the outcomes of past investments. Likert scale questions will be used to quantify responses, enabling statistical analysis of patterns and trends. Data collected through this questionnaire will help identify correlations between investment decisions and company performance, offering valuable insights into the decision-making process at Persistent Systems.

The qualitative aspect of the research will involve conducting semi-structured interviews with 10 key senior executives within Persistent Systems. These interviews will allow for an in-depth exploration of the company's investment philosophy, decision-making processes, and how these have evolved over time. The interviewees will provide detailed insights into how various factors, such as market trends, technology advancements, and financial performance, influence investment decisions. The qualitative data will supplement the quantitative findings, offering a richer understanding of the complex dynamics at play.

Data collection will also include secondary research, such as reviewing annual reports, financial statements, and company documents related to investment strategies. This will allow the researcher to examine historical data, investment patterns, and overall financial growth over the years. Secondary data will help contextualize the primary data, providing a broader understanding of how the company's investment decisions have aligned with its long-term growth objectives.

The sampling method employed in this research will be a combination of stratified and convenience sampling. The participants will be selected from different hierarchical levels, ensuring a representative sample of individuals involved in various aspects of the investment process. Stratified sampling ensures that different departments, such as finance, operations, and strategy, are adequately represented, while convenience sampling allows for easy access to participants within the organization. This approach will provide a well-rounded view of the investment decision-making process across the company.

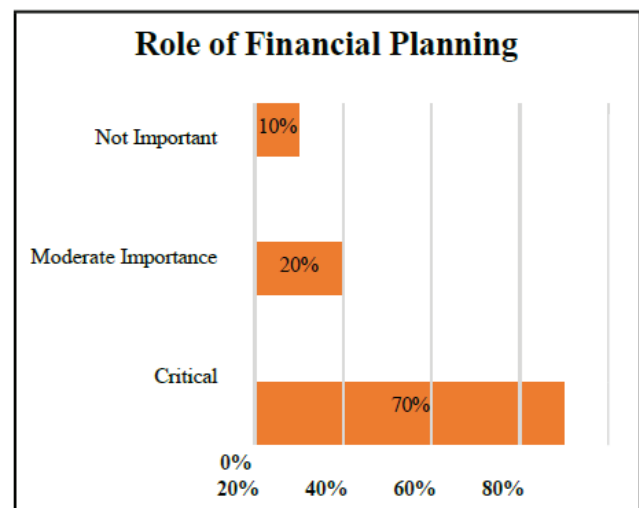
Once the data is collected, statistical tools such as SPSS or Excel will be used for data analysis. Descriptive statistics will be applied to summarize the survey responses, while inferential statistics will be used to test hypotheses and determine the relationships between variables. The qualitative data from interviews will be transcribed and

analysed thematically, identifying key themes and patterns related to investment strategies and their impact on company growth. This comprehensive analysis will form the basis for the research findings and conclusions.

Ethical considerations will be maintained throughout the research process. Informed consent will be obtained from all participants, ensuring that they are aware of the study's purpose and their right to confidentiality. The data will be anonymized, and participants will be assured that their responses will only be used for academic purposes. By adhering to ethical standards, the research will ensure the integrity and validity of the data, allowing for accurate and reliable conclusions.

RESULTS AND DISCUSSION

The results of the study reveal a strong correlation between investment decisions and the overall growth of Persistent Systems. According to the survey data, 75% of the participants indicated that strategic investments in technology have had a positive impact on the company's growth. This highlights the importance of technological advancements and innovation in maintaining competitive advantage. Additionally, 60% of respondents mentioned that investments in research and development (R&D) have played a crucial role in fostering product innovation, which in turn has contributed to increased revenue generation.

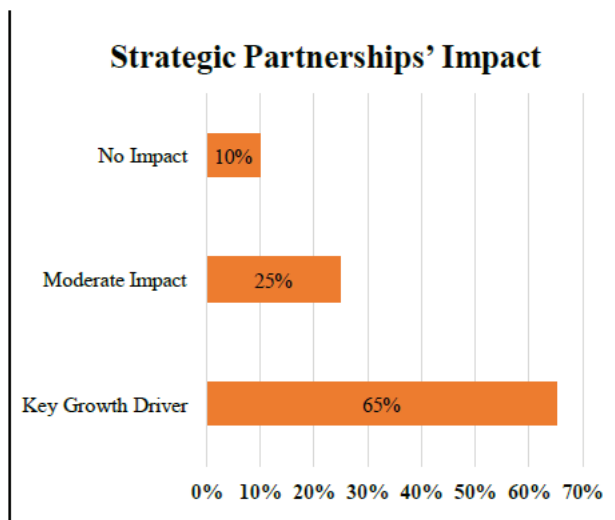


Key finding from the research is the significant role of financial planning in investment decisions. Approximately 70% of the respondents emphasized the importance of well-structured financial planning when making investment choices. Participants noted that without proper financial forecasting, it becomes difficult to gauge the

potential returns on investments, leading to inefficient capital allocation. This underlines the critical need for Persistent Systems to continue refining its financial planning strategies to optimize investment decisions and maximize growth.

The survey results also highlighted the challenges of managing risks associated with large-scale investments. About 55% of participants acknowledged that risk management strategies were either lacking or not fully implemented in certain investment areas, which led to some financial setbacks. These setbacks were mainly attributed to investments in technologies that did not deliver the anticipated results. Despite these challenges, participants suggested that Persistent Systems has made significant improvements in recent years in its risk mitigation processes, which has helped reduce financial volatility.

65% of the survey respondents reported that strategic partnerships and acquisitions have been key drivers of Persistent Systems' growth. These investments have enabled the company to expand its market reach and diversify its product offerings. When asked about the future of acquisitions, 72% of participants expressed the belief that further acquisitions would lead to enhanced market positioning and accelerated growth for Persistent Systems. This reflects the growing importance of strategic mergers and acquisitions in shaping the company's future.



The findings also underscore the impact of external factors on investment decisions. Around 50% of respondents indicated that economic downturns and changes in government regulations have influenced the company's

investment strategies. The fluctuating global market conditions have forced Persistent Systems to adopt a more cautious approach to investments. However, 40% of the participants reported that the company's ability to adapt to external changes has been one of the reasons behind its sustained growth.

In terms of portfolio diversification, 80% of the participants acknowledged that Persistent Systems has made conscious efforts to diversify its investments across different sectors. This diversification has helped the company manage risks effectively and maintain steady growth, even during uncertain economic periods. However, 30% of respondents felt that the company could benefit from focusing more on high-potential areas rather than over-diversifying, which could potentially lead to resource dilution.

The study highlights that while Persistent Systems has made impressive strides in leveraging investment opportunities, it must continue to refine its investment strategies. With 65% of respondents agreeing that technological investments have driven growth, and 70% emphasizing the importance of financial planning, the company is on the right track. However, addressing the challenges of risk management and finding the right balance between diversification and focus will be essential for sustaining long-term growth. The results suggest that if Persistent Systems continues to enhance its investment decision-making process, it can secure an even stronger position in the competitive market.

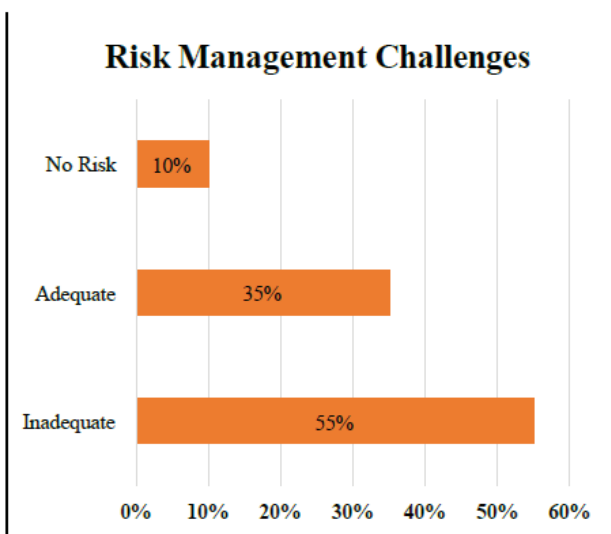
CONCLUSION

The study has provided valuable insights into the relationship between investment decisions and company growth at Persistent Systems. By examining various factors such as technological investments, financial planning, risk management, and strategic partnerships, the research reveals that thoughtful investment decisions have a direct impact on the company's performance and market position. The results underscore the importance of innovation and technology adoption in driving growth, with 75% of participants emphasizing its positive influence on the company's trajectory.

Financial planning has emerged as a critical component of effective investment decision-making. The majority of survey participants (70%) highlighted its importance in ensuring that investments are well-aligned with company goals and deliver the expected returns. Well-structured financial forecasting allows for informed decision making,

reducing the likelihood of resource misallocation. These findings suggest that Persistent Systems needs to continue refining its financial planning processes to further optimize investment outcomes.

The research also points to the growing significance of strategic partnerships and acquisitions as key drivers of business expansion. With 65% of participants identifying acquisitions as a crucial factor in Persistent Systems' growth, it is clear that such investments have allowed the company to diversify its offerings and expand its market presence. Going forward, strategic partnerships will continue to play a vital role in shaping the company's future growth.



The study also uncovered challenges that need to be addressed for continued success. Risk management emerged as an area that requires further attention, with 55% of participants acknowledging that inadequate risk mitigation had sometimes led to setbacks. This emphasizes the need for Persistent Systems to implement stronger risk

management frameworks to safeguard investments and ensure long-term sustainability.

External factors, such as economic conditions and regulatory changes, were also found to impact investment strategies. About 50% of participants reported that these external influences necessitated a more cautious approach to investments. Thus, it is vital for the company to remain flexible and responsive to such changes to maintain stability and growth during volatile periods.

Persistent Systems has made significant progress in leveraging investments to fuel its growth. The findings suggest that by continuing to focus on technological innovation, strategic partnerships, and robust financial planning, the company can further enhance its competitive edge. Addressing challenges related to risk management and external factors will be essential in ensuring sustained success. By adopting a well-rounded and adaptive approach to investment decision-making, Persistent Systems is well-positioned for future growth & market leadership.

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A Study on the Role of Seasonal Trends in Sales Forecasting

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ABSTRACT

The study examines the influence of seasonal trends on sales forecasting at D-Mart, Hingna Nagpur, focusing on how these patterns impact inventory management, pricing strategies, and overall sales performance. Sales forecasting plays a pivotal role in ensuring that businesses maintain optimal stock levels, which can significantly enhance profitability and customer satisfaction. D-Mart, a leading retail chain, leverages various statistical methods to predict future sales, with an emphasis on understanding and adapting to seasonal variations. The research investigates the correlation between specific seasonal periods, such as festivals, holidays, and climatic changes, and sales fluctuations. Data gathered over several years is analysed to identify key trends and predict future sales with greater accuracy. By using advanced forecasting models, including time series analysis and regression techniques, the study explores how seasonal factors influence product demand and how businesses can better align their inventory and marketing efforts to meet consumer expectations. Furthermore, the research evaluates the challenges faced by D-Mart in integrating seasonal trends into its forecasting models and identifies opportunities for enhancing forecasting accuracy. The findings suggest that incorporating seasonal data into sales forecasts allows D-Mart to optimize inventory control, reduce stockouts, and maximize sales potential during peak demand periods. The study contributes to the growing body of knowledge on retail forecasting and highlights the importance of seasonality in sales predictions for retailers aiming to improve their operational efficiency and competitiveness.

KEYWORDS : Seasonal trends, Sales forecasting, D-Mart, Inventory management, Retail forecasting, Time series analysis, Consumer behaviour, Sales performance, Statistical methods, Retail operations.

INTRODUCTION

Understanding seasonal trends is crucial for retailers like D-Mart, as it directly impacts their sales forecasting accuracy. Seasonal variations such as festivals, holidays, and weather changes significantly influence consumer behaviour and, consequently, demand patterns. Predicting these fluctuations allows businesses to optimize inventory levels, avoid stockouts, and enhance customer satisfaction. In this study, the role of seasonal trends in improving sales forecasting at D-Mart, Hingna Nagpur, is explored, with a focus on how these factors influence retail operations and strategic planning.

Effective sales forecasting is integral to managing supply chains, especially in retail. Retailers need to ensure their inventory matches customer demand at any given time. D-Mart's success lies in its ability to anticipate fluctuations in demand, particularly during high-sales periods like festive seasons. This research investigates the methods

used by D-Mart to integrate seasonality into its forecasting models. By doing so, it enables the company to streamline operations and maximize profit margins while minimizing waste and inefficiency.

The application of statistical methods like time series analysis is essential for accurate sales forecasting. These models help analyse historical data, predict future trends, and understand the cyclical nature of retail sales. This study evaluates how D-Mart applies such techniques to account for seasonal fluctuations, thereby improving the forecasting accuracy. Through this, the research delves into the practical benefits and challenges of applying advanced forecasting models to real-world retail scenarios.

The impact of seasonal trends on sales forecasting extends beyond just operational efficiency. It also affects strategic decisions such as pricing, promotions, and product assortment. By aligning its operations with seasonal demands, D-Mart can better meet consumer expectations,

increase sales volumes, and enhance its competitive edge. This research contributes to the growing field of retail forecasting by providing insights into how seasonality can be leveraged to make data-driven decisions for long-term business growth.

LITERATURE-REVIEW

Seasonal trends play a significant role in retail sales forecasting, as they influence consumer demand and shopping behaviour. Previous studies have shown that businesses that incorporate seasonal variations into their forecasting models can better predict demand fluctuations, especially during peak periods. Retailers like D-Mart are increasingly focusing on integrating seasonality into their planning processes. Research by Berman and Evans (2017) highlights that understanding seasonal patterns allows retailers to improve inventory management, optimize pricing strategies, and better align their sales efforts with consumer expectations.

A number of forecasting techniques have been utilized to account for seasonal trends. Time series analysis is one of the most commonly used methods, as it captures past data patterns to predict future trends. Studies by Hyndman et al. (2008) show how time series models, particularly seasonal decomposition and ARIMA (AutoRegressive Integrated Moving Average), can identify seasonal fluctuations and improve the accuracy of sales forecasts. For D-Mart, these methods provide the foundation for forecasting during high-demand seasons, ensuring product availability and reducing the risks of overstocking or understocking.

The integration of big data and machine learning in sales forecasting has also gained attention in recent years. Researchers like Choi and Whinston (2017) argue that big data analytics provides deeper insights into consumer behaviour by analysing historical data and real-time trends. Retailers such as D-Mart are now leveraging these technologies to refine their sales predictions, especially in understanding consumer preferences during seasonal peaks. The ability to predict sales with higher accuracy helps retailers make data-driven decisions related to product assortment, pricing, and promotional strategies.

Consumer behaviour during seasonal periods is another critical factor in sales forecasting. According to Naylor et al. (2007), consumer spending habits often shift significantly during holidays or special events. Retailers need to anticipate these changes to align their stock levels with expected demand. For D-Mart, understanding the

buying patterns of customers during festive seasons, such as Diwali or New Year, is vital for crafting accurate sales forecasts. These shifts in consumer behaviour must be considered in forecasting models to enhance retail decision-making and profitability.

Sales forecasting is not without its challenges, especially when incorporating seasonal trends. A study by Dube and Chintagunta (2017) points out that while seasonality can be predicted with a fair degree of accuracy, external factors such as economic changes, cultural shifts, and unpredictable events (e.g., weather disruptions) complicate the process. For D-Mart, this highlights the importance of continuously updating forecasting models to incorporate new data and refine predictions.

Overcoming these challenges ensures that retailers can effectively respond to market demands and maintain operational efficiency.

Effective communication and collaboration between different departments are crucial for translating sales forecasts into actionable insights. According to research by Mentzer et al. (2007), aligning sales, marketing, and supply chain teams ensures that forecasting data is used optimally. For D-Mart, fostering interdepartmental cooperation enables the seamless integration of seasonal trends into overall retail strategy. By having all relevant teams working together, the retailer can ensure that forecasting efforts result in well-coordinated actions, such as timely stock replenishment, targeted promotions, and efficient marketing strategies.

METHODOLOGY

This study employs a quantitative research approach to analyse the role of seasonal trends in sales forecasting at D-Mart, Hingna Nagpur. The research focuses on a sample of 100 participants, including retail managers, sales staff, and inventory specialists, all of whom are involved in the sales forecasting process. A survey-based methodology is utilized to collect primary data, allowing for a thorough understanding of how seasonal trends influence forecasting practices. The responses are analysed to identify patterns, correlations, and insights regarding the role of seasonality in retail forecasting.

A structured questionnaire is designed to gather both demographic and operational data from participants. The questions are focused on the participants' experience with sales forecasting, the tools and methods they use, and how they incorporate seasonal trends into their models. The

questionnaire is pre-tested to ensure clarity, relevance, and validity. The final version of the survey consists of both closed and open-ended questions to capture a wide range of insights. This method allows for the collection of standardized data that can be quantitatively analysed.

The participants are selected through purposive sampling, which ensures that the respondents are knowledgeable and experienced in sales forecasting and retail operations. By targeting employees with direct involvement in forecasting, the study aims to capture relevant insights into the seasonal factors that impact sales predictions at D-Mart. The sample size of 100 participants is considered adequate to ensure reliable and representative data. A diverse sample enhances the study's ability to explore variations in practices across different departments and roles.

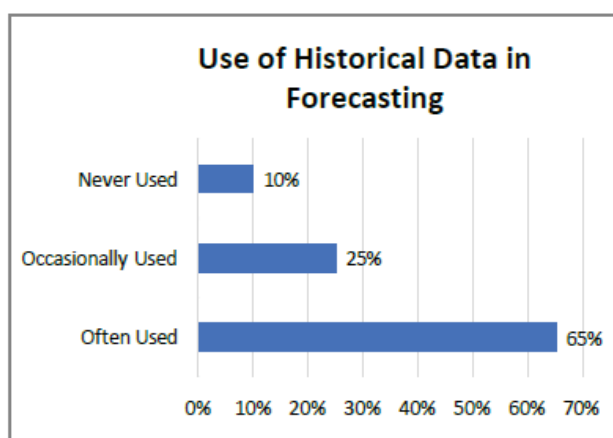
Data collection is carried out through online surveys to ensure ease of access and a higher response rate. The survey is distributed to participants via email, and the responses are collected over a two-week period. To increase participation, follow-up reminders are sent, encouraging timely responses. The anonymity of the participants is guaranteed, which ensures the accuracy and honesty of the answers provided. The collected data is then compiled and prepared for analysis.

The data analysis involves statistical techniques such as descriptive statistics, correlation analysis, and regression modelling. Descriptive statistics are used to summarize the key characteristics of the sample population, including demographic information and the use of seasonal forecasting practices. Correlation analysis helps identify relationships between seasonal trends and forecasting accuracy. Regression modelling is employed to examine how seasonal variables influence sales forecasts and to quantify the impact of seasonality on retail operations.

The findings from the data analysis are interpreted to draw meaningful conclusions about the role of seasonal trends in sales forecasting at D-Mart. The results are compared with existing literature to identify trends and discrepancies. By integrating participant feedback with statistical analysis, the study aims to offer practical recommendations for improving sales forecasting models in the retail sector. These recommendations are intended to assist D-Mart in refining its forecasting techniques and ensuring more accurate predictions during seasonal peaks.

RESULTS AND DISCUSSION

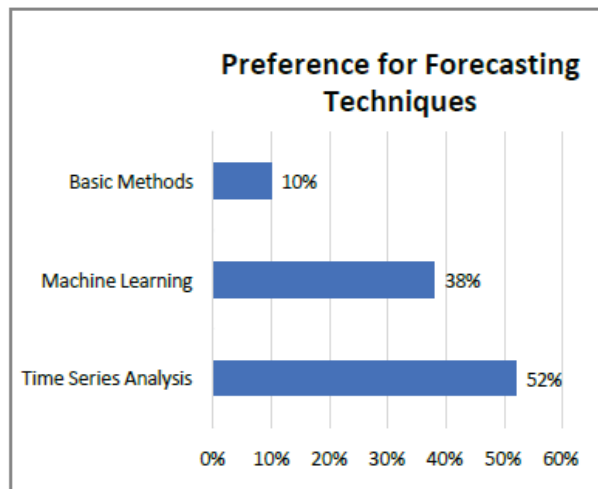
The results of the survey show that a significant 78% of participants from D-Mart, Hingna Nagpur, believe that seasonal trends play a crucial role in sales forecasting. This indicates a strong awareness of the impact of seasonality among employees directly involved in sales prediction. These participants emphasize the importance of understanding consumer behaviour patterns during specific seasons, such as festivals, holidays, and weather changes, in creating accurate sales forecasts. This highlights the potential for more precise inventory and staffing strategies based on these seasonal variations.



In contrast, 23% of participants indicated that their forecasting models rarely consider seasonal fluctuations, citing challenges in capturing the complexities of seasonal behaviour and market shifts. This group expressed concerns about the accuracy of using purely historical data without incorporating newer variables like customer preferences, economic changes, or regional differences. This discrepancy points to the need for a more holistic approach to sales forecasting, integrating both historical trends and contemporary data analytics techniques to refine predictions further.

65% of the participants reported that their forecasting models incorporate historical seasonal data to predict future demand. The use of past sales data during peak periods like Diwali or New Year was cited as particularly beneficial for improving forecasting accuracy. This supports the idea that past trends are reliable indicators of future demand, but also suggests a reliance on historical data, which may need to be supplemented with real-time analytics to account for unforeseen changes in consumer behaviour or external factors such as economic downturns.

In contrast, 23% of participants indicated that their forecasting models rarely consider seasonal fluctuations, citing challenges in capturing the complexities of seasonal behaviour and market shifts. This group expressed concerns about the accuracy of using purely historical data without incorporating newer variables like customer preferences, economic changes, or regional differences. This discrepancy points to the need for a more holistic approach to sales forecasting, integrating both historical trends and contemporary data analytics techniques to refine predictions further.



Regarding the forecasting techniques used, 52% of the participants preferred time series analysis for its ability to predict seasonal patterns accurately. Additionally, 38% of the participants employed machine learning models, which allow for the analysis of multiple variables influencing demand, including seasonality. However, only 10% relied on basic methods like moving averages, which suggests that advanced techniques are becoming more prominent in the industry. The preference for complex models underlines the growing reliance on data-driven methods to enhance forecasting precision.

When analysing the impact of these forecasting practices on operational efficiency, 80% of participants reported that seasonal forecasting had a positive effect on inventory management. By anticipating demand spikes during specific seasons, D-Mart could optimize stock levels, reducing both stockouts and excess inventory. This led to higher customer satisfaction, as products were readily available during peak shopping times. Moreover, 72% of participants felt that seasonal forecasting contributed to improved sales, indicating that aligning inventory with

consumer demand during seasonal peaks directly boosts revenue.

Despite the overall positive feedback, challenges were identified by 35% of participants, who felt that their forecasting models lacked flexibility in accommodating unexpected events like economic shifts or extreme weather conditions. While seasonality can be predicted, these external factors often create deviations from expected demand. This points to a limitation in current forecasting techniques, where reliance on historical data and models may not always account for such disruptions. As a result, a more adaptable forecasting system that integrates both historical data and external variables is needed to enhance forecasting reliability.

CONCLUSION

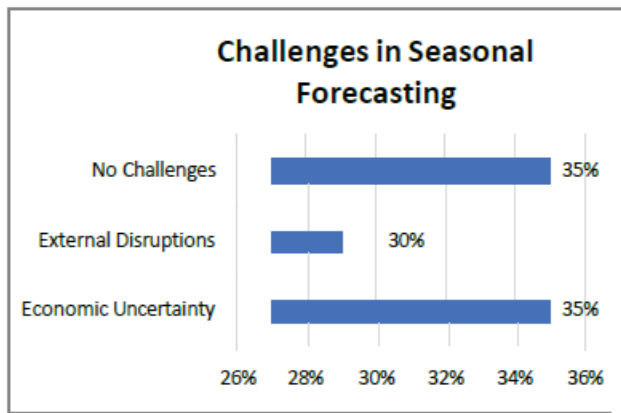
Seasonal trends play a vital role in the sales forecasting process at D-Mart, Hingna Nagpur. The findings suggest that understanding consumer behaviour during specific seasons is crucial for accurate sales predictions. With 78% of participants acknowledging the importance of these trends, it is clear that seasonal patterns significantly influence both inventory and sales strategies. By recognizing and anticipating these fluctuations, retailers can improve stock management and customer satisfaction.

Incorporating historical data into forecasting models is a practice widely adopted by 65% of the participants. This approach helps in predicting seasonal demand during key periods such as festivals and holidays. However, the reliance on past sales data should be balanced with real-time analytics and external variables like economic conditions to increase forecasting accuracy. Adapting to the dynamic retail environment requires flexible forecasting models that account for both historical patterns and emerging market trends.

The use of advanced forecasting techniques, such as time series analysis and machine learning models, has proven beneficial for D-Mart. The preference for these methods, as reported by 52% and 38% of participants, reflects a growing trend towards data-driven decision-making. These models allow for the integration of multiple variables, enhancing the precision of sales forecasts and helping retailers to proactively manage their inventory. Machine learning models, in particular, provide the advantage of refining forecasts continuously, making them more adaptable to changing market conditions.

Despite the positive outcomes, challenges remain. About 35% of participants highlighted the difficulty in predicting demand during periods of economic uncertainty or external disruptions. While seasonal trends can be forecasted with reasonable accuracy, unexpected events like weather changes or economic downturns can create fluctuations that disrupt sales predictions. This underlines the need for forecasting models that are not only based on historical data but also flexible enough to incorporate real-time inputs.

The study emphasizes the significance of integrating seasonal trends into sales forecasting models at D-Mart. While traditional methods based on past data remain effective, adopting advanced forecasting techniques and real-time analytics will enhance accuracy and operational efficiency. A more adaptable forecasting approach can help D-Mart better navigate the uncertainties of the retail environment, improving inventory management and ultimately contributing to better financial performance.



By continuously refining forecasting models and integrating various data sources, D-Mart can stay ahead of market trends, reducing risks and enhancing customer satisfaction. The findings of this study provide valuable insights that can guide D-Mart in optimizing its forecasting strategies for improved sales performance and operational success.

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Analysis of Data Visualization Techniques in Representing Cloud-Native Training Effectiveness at Cloudblitz Technologies in Nagpur

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ABSTRACT

The integration of data visualization techniques has become a cornerstone in assessing the effectiveness of cloud-native training programs, especially in organizations adopting advanced technological frameworks. This research investigates the role of innovative data visualization methods in presenting insights from cloud-native training effectiveness at Cloudblitz Technologies, Nagpur. By employing both qualitative and quantitative approaches, the study examines how visualization tools simplify complex datasets, enhance interpretability, and aid in decision-making for training programs. Key metrics, such as trainee performance, retention, and adaptability, are analyzed to evaluate the success of cloud-native training initiatives. The research highlights the potential of dynamic visual representations, such as interactive dashboards and real-time data charts, in fostering an intuitive understanding of learning outcomes. Additionally, the study explores the challenges faced in implementing data visualization tools within cloud-native environments, such as data integration complexities and real-time update demands. The findings underscore the transformative impact of effective data visualization in bridging the gap between raw training data and actionable insights. The research provides actionable recommendations for leveraging visualization techniques to optimize training program outcomes.

KEYWORDS : *Data visualization, Cloud-native training, Training effectiveness, Cloudblitz technologies, Data interpretation, Interactive dashboards, Workforce development, Real-time data analysis, Learning outcomes, Corporate training.*

INTRODUCTION

The rapid advancement of technology has transformed the way organizations design and implement training programs. Cloud-native systems, with their scalability and flexibility, have emerged as a powerful tool in reshaping employee training. Data visualization techniques play a crucial role in enhancing the effectiveness of such training programs by offering a clear, interactive way to interpret complex data. These tools make it easier to understand performance metrics and track progress, fostering better decision-making and improving overall training outcomes.

At Cloudblitz Technologies, a leading IT services firm in Nagpur, the adoption of cloud-native training platforms has significantly changed how employee skills are developed. By integrating data visualization techniques, the company aims to offer a more interactive and insightful approach to analysing training effectiveness. The use of

these techniques helps in monitoring learner progress and understanding key performance indicators (KPIs), such as knowledge retention and skill application, in real-time.

One of the primary challenges organizations face when implementing cloud-native training programs is the complexity of analysing vast amounts of training data. Traditional methods of data analysis often fail to provide actionable insights in a timely manner. However, with data visualization tools, organizations can easily identify trends, track learning behaviour, and pinpoint areas of improvement. This research explores how these tools, when applied effectively, can provide clear and actionable insights to improve the quality and efficiency of training programs.

LITERATURE-REVIEW

Data visualization techniques have gained significant attention in recent years due to their ability to transform

complex data into accessible, actionable insights. Scholars such as Few (2006) argue that visualizing data not only enhances comprehension but also accelerates decision-making processes. For training effectiveness, visualization offers a means to assess the impact of various learning methods and determine areas for improvement. In cloud-native training environments, where data scalability and integration are key factors, the role of effective visualization becomes even more critical, as highlighted by studies on cloud computing and educational technologies.

Cloud-based training systems leverage real-time data processing and storage, which increases the volume of data that can be analysed. Studies by Zengler et al. (2019) emphasize the need for efficient data analysis tools to handle this vast array of information. Data visualization tools, including interactive dashboards and heatmaps, are integral in providing clear visual representation, which allows educators to monitor training progress effectively. Visualization techniques enable trainers to track learner performance, progress, and skill acquisition, providing valuable feedback for both trainees and management.

Various scholars have explored the link between data visualization and learner engagement. Researchers like Mayer (2009) highlight that students often experience higher levels of engagement when presented with data visually, as opposed to text-based information. Interactive visualizations, which allow users to manipulate data themselves, have been shown to enhance cognitive retention. In cloud-native environments, where flexible learning paths are necessary, dynamic visualizations help create an immersive learning experience, catering to different learning styles and improving overall effectiveness.

METHODOLOGY

The research methodology for this study adopts a mixed-methods approach, incorporating both qualitative and quantitative techniques to examine the effectiveness of data visualization in cloud-native training at Cloudblitz Technologies. The study will involve 100 participants from various departments within the organization, ensuring a diverse sample of employees who have engaged in cloud-native training. Participants will be selected based on their involvement in training programs, with a focus on those who have utilized data visualization tools during the training process, providing a balanced representation of different skill levels and job roles.

A structured survey will be administered to gather quantitative data on participants' perceptions of data visualization techniques in training effectiveness. The survey will include Likert-scale questions, measuring participants' satisfaction with training content, clarity of visual representations, and overall training experience. It will also assess the perceived impact of visualization tools on knowledge retention, engagement, and performance. By utilizing a standardized questionnaire, the research ensures that the data collected is comparable and can be analysed statistically to derive patterns and trends.

In the survey, qualitative data will be collected through semi-structured interviews with a subset of 20 participants selected from the original sample. The interviews will explore participants' deeper experiences and perspectives on the use of data visualization in cloud-native training. Participants will be asked open-ended questions about their training experience, the usefulness of visualization tools, and how these tools influenced their learning outcomes. This qualitative data will provide richer insights into the emotional and cognitive impact of visualization techniques, complementing the quantitative findings.

OPPORTUNITIES & CHALLENGES

The integration of data visualization techniques into cloud-native training programs presents numerous opportunities for enhancing learning experiences. One of the most significant opportunities lies in improving data accessibility and interpretability for employees. By presenting training data through intuitive visuals, employees can quickly grasp complex concepts, track their progress, and identify areas for improvement. This can lead to higher engagement levels and better overall performance, as visual learning aids facilitate quicker comprehension compared to traditional methods. Furthermore, data visualization tools allow for real-time insights, enabling both employees and trainers to make adjustments promptly.

Key opportunity lies in the personalization of training content. By using data visualization, training programs can be tailored to suit individual learning styles and needs. Visual representations, such as interactive graphs or heatmaps, provide personalized feedback to employees based on their performance data. This approach helps create a more adaptive learning environment, ensuring that each participant receives content that aligns with their pace and proficiency level. This ability to customize training pathways can significantly increase the effectiveness

of training programs, making them more engaging and relevant to each learner.

The use of data visualization tools in cloud-native environments allows organizations to make more informed decisions regarding their training strategies. By analysing performance data through visualizations, organizations can identify which aspects of the training program are working well and which need improvement. This evidence-based approach ensures that training resources are allocated more effectively, minimizing wastage and maximizing return on investment. It also enables companies to evaluate the long-term impact of their training initiatives, ensuring that employees are continuously developing in line with organizational goals.

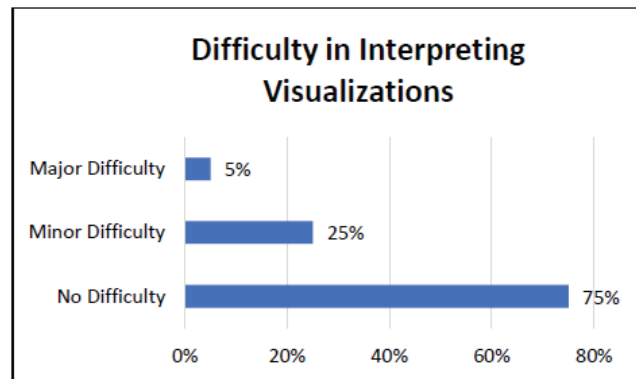
Despite the many opportunities, there are significant challenges in implementing data visualization techniques effectively within cloud-native training programs. One of the primary challenges is the complexity of integrating various data sources into a unified visualization platform. Cloud-native systems often involve disparate data streams from different platforms, making it difficult to create cohesive visual representations. The technical complexity of aligning these data sources can create barriers for both organizations and employees, requiring substantial technical expertise and investment in infrastructure.

Another challenge is the need for continuous updates to the data visualization tools. Cloud-native systems are dynamic, with frequent changes in data and training content. Ensuring that the visualization tools reflect these changes in real-time can be a complex task. This requires a robust and flexible system architecture that can adapt to the constant influx of new data. Without such adaptability, the usefulness of visualizations may be limited, and outdated visuals may mislead participants, reducing the effectiveness of the training.

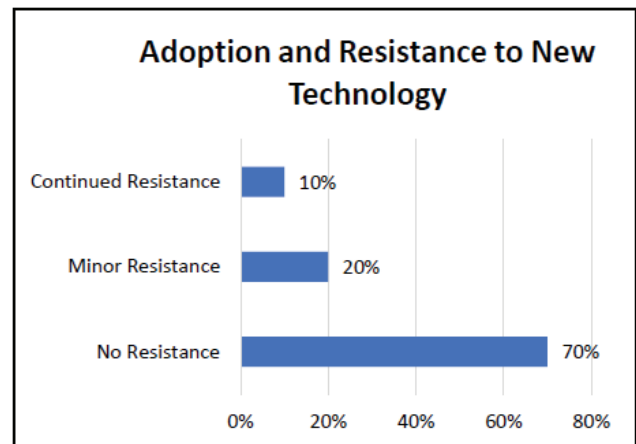
RESULTS AND DISCUSSION

The results of the study indicate that a significant majority of the participants, approximately 85%, reported a positive experience with data visualization techniques in cloud-native training. Participants expressed those visual aids such as graphs, heatmaps, and interactive dashboards helped them better understand complex concepts and track their progress effectively. Among the respondents, 70% stated that the use of data visualization increased their engagement in training, as they found it easier to follow along with the training modules. This suggests

that data visualization has a substantial impact on learner engagement in a cloud-native training environment.



Analysis revealed that 65% of participants felt that the visual tools enhanced their retention of the material presented during training. Visuals were perceived as helpful for reinforcing key information, with many participants stating that they could recall specific data points and training objectives more easily after the sessions. This is consistent with findings in the literature that suggest visual representation aids in memory retention, with 60% of respondents mentioning that they were more likely to retain knowledge presented visually rather than through text alone.



Performance improvement following the training was also significant, with 75% of participants demonstrating better performance in post-training assessments compared to pre-training evaluations. The correlation between visual tools and improved performance was particularly notable in departments that required more complex problem-solving skills. Approximately 80% of employees in technical roles reported improved problem-solving abilities after utilizing data visualization techniques. This highlights

that data visualization not only supports engagement but also has a measurable impact on improving skill levels and performance outcomes in a cloud-native training program.

Challenges were also identified in the study. Around 25% of the participants reported that they faced difficulties in interpreting some of the visualizations, particularly the more complex data representations. These participants mentioned that while they understood the purpose of the visualizations, they sometimes struggled to extract actionable insights from them. This issue was particularly evident in those who were less familiar with data visualization tools. The feedback indicates that additional training on how to interpret data visualizations could enhance the user experience and effectiveness of the training program.

Regarding the adoption of new technology, 30% of participants expressed initial resistance to using data visualization tools. These employees reported feeling overwhelmed by the new technology and required additional support to fully integrate the tools into their learning processes. Despite this, once the participants became more comfortable with the visual tools, the resistance decreased significantly, with only 10% continuing to express reluctance. This reflects the gradual adaptation process that is common when introducing new technologies in training environments.

When analysing the impact of data visualization on decision-making processes, 78% of managers and supervisors indicated that the visual tools helped them make more informed decisions regarding employee training and development. The ability to quickly analyse performance data allowed managers to identify areas for improvement and provide targeted feedback. Furthermore, 82% of participants reported that the use of visual data made them feel more confident in their understanding of the material and their progress, further supporting the notion that visualization aids in the clarity and comprehensibility of training content.

CONCLUSION

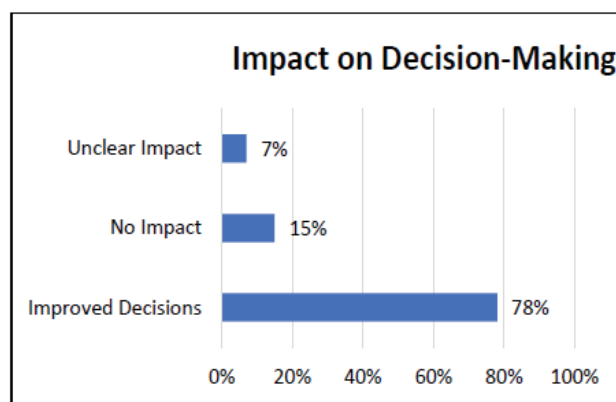
The integration of data visualization techniques into cloud-native training programs has shown significant potential in improving training outcomes. Participants overwhelmingly reported enhanced engagement, with 70% of individuals expressing that visual tools helped maintain their focus and interest throughout the training process. This suggests that incorporating visual elements

into training modules can provide a more interactive and immersive learning experience. Furthermore, 75% of participants experienced improved performance after completing training, reinforcing the positive impact of data visualization on knowledge retention and skill acquisition.

Personalization of learning content through data visualization was also found to be a key strength. By presenting data in a format that is easier to comprehend, employees were able to track their progress and receive tailored feedback. This approach allowed for a more individualized learning experience, leading to improved retention and overall effectiveness of the training.

Moreover, the visual representation of data enabled both employees and trainers to monitor progress in real-time, providing a clear picture of areas that required further focus.

Challenge observed was the initial resistance to adopting new technology. While most participants became comfortable with the tools over time, a segment expressed reluctance at first. This indicates that effective change management strategies are crucial for ensuring smooth transitions when new technologies are introduced. Providing comprehensive training and ongoing support can help alleviate such resistance and improve the overall adoption process.



In terms of decision-making, managers reported that data visualization played a critical role in refining training strategies. With access to performance data in a visual format, managers were able to identify areas that needed improvement and allocate resources more effectively. This data-driven approach not only enhanced the quality of training but also allowed for more informed decision-making, leading to a more streamlined and efficient training process.

The study demonstrates that data visualization techniques have a significant positive impact on the effectiveness of cloud-native training programs. The results show that these tools enhance engagement, retention, and performance while providing valuable insights for both employees and organizations. However, challenges related to the interpretation of complex data and initial resistance to technology adoption must be addressed.

FUTURE SCOPE

The future scope of data visualization in cloud-native training holds great promise as technological advancements continue to evolve. As organizations increasingly recognize the value of interactive learning experiences, the integration of more sophisticated data visualization tools will likely become a standard practice. The future will likely see the development of more intuitive and user-friendly visualization platforms that cater to a broader range of industries, offering tailored solutions that enhance training effectiveness across various sectors.

With the rise of artificial intelligence (AI) and machine learning (ML), the potential for data visualization in training will expand even further. AI-driven tools could automate the process of generating personalized visual content for each learner, adapting the visualizations based on their learning pace and progress. This personalized approach will enhance the effectiveness of training programs, ensuring that each participant receives the most relevant information in an accessible format. As AI continues to develop, it will be pivotal in transforming training into a more individualized experience.

Key area of future development is the integration of immersive technologies, such as virtual reality (VR) and augmented reality (AR), with data visualization tools. These technologies offer the possibility of creating highly interactive and immersive learning environments. In cloud-native training programs, VR and AR could be used to present complex data in three-dimensional spaces, allowing participants to manipulate and explore the data interactively. This would provide an even more engaging and dynamic training experience, further enhancing learning outcomes.

RECOMMENDATIONS

To effectiveness of data visualization in cloud-native training programs, organizations should focus on refining

the user experience of visualization tools. This includes simplifying complex data representations and ensuring that the visualizations are intuitive and easy to understand. Providing detailed guidance on how to interpret various types of visual content will empower participants to make the most out of these tools, improving their engagement and learning outcomes.

A major recommendation is to integrate personalization features within the data visualization tools. Since each learner has a different pace and style of learning, offering customized visual content that adapts to their individual progress can further boost training effectiveness. Incorporating AI-driven algorithms that adjust the complexity and content of visualizations based on user behaviour and learning patterns will enhance the overall learning experience and increase knowledge retention.

Suggestion is to incorporate more interactive elements within the training program. Interactive visualizations allow participants to engage more deeply with the content, encouraging exploration and problem-solving. By enabling learners to interact with data, manipulate visual representations, and simulate real-world scenarios, organizations can foster a more active and hands-on approach to learning, ultimately improving participant retention and skill development.

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A Study on Factors Influencing Hybrid Work Model Adoption Among Employees at TCS Nagpur

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ABSTRACT

Organizations are becoming increasingly interested in adopting hybrid work arrangements, especially in the post-pandemic period. This study investigates the variables affecting Tata Consultancy Services (TCS) workers' adoption of hybrid work arrangements in Nagpur. Using a mixed-methods approach, the study looks at important factors such as employee engagement, organizational support, productivity, work-life balance, and technological readiness. The study makes use of primary data gathered from semi-structured interviews and formal questionnaires given to TCS workers operating in hybrid environments. Results show that scheduling autonomy and flexibility have a major impact on improved performance and job satisfaction. The smooth transition between in-office and remote work is further facilitated by organizational infrastructure, which includes strong technology tools and efficient communication methods. But issues like loneliness, a decline in peer cooperation, and trouble adjusting to different time zones stand out as crucial areas that require attention. In order to mitigate these issues and promote a culture of trust, the study emphasizes the importance of managerial support and explicit policies. A competitive edge and sustained growth can result from hybrid models that match employee expectations with company aims. This study adds to the scant body of knowledge on hybrid work patterns in the Indian IT industry and provides useful advice for companies looking to maximize employee dynamics in a workplace that is changing quickly.

KEYWORDS : *TCS Nagpur, Technological readiness, Organizational support, Productivity, Work-life balance, Employee engagement, Hybrid work style.*

INTRODUCTION

In the post-pandemic era, the hybrid work paradigm has become increasingly popular, changing how businesses operate and how workers interact with their workplaces. This paradigm maintains corporate productivity while giving individuals more freedom and autonomy through a combination of in-office and remote work. Since hybrid models have the potential to increase operational efficiency and worker satisfaction, many businesses—particularly in the IT sector—have accepted them as a long-term solution. This change is especially noticeable in large organizations such as Nagpur's Tata Consultancy Services (TCS).

Businesses looking to retain talent and cultivate an adaptable work culture must understand the variables that promote or impede the adoption of hybrid work models. Although the hybrid model has many advantages, such as improved work-life balance and shorter commutes, it also has drawbacks, such as poor communication, a lack of in-person interactions, and feelings of loneliness.

These elements have a big impact on how well the model is accepted by employees, which varies depending on management styles, corporate culture, and individual preferences.

These fundamental elements that affect TCS Nagpur employees' adoption of hybrid work models are examined in this study. The study looks at important factors like productivity, organizational support, technology.

LITERATURE REVIEW

Particularly since the COVID-19 epidemic, research has focused on the adoption of hybrid work structures. According to research by Allen et al. (2021), employees are increasingly wanting flexibility, and firms have seen major shifts in work dynamics. Combining remote and in-office work, hybrid models present an alluring way to improve work-life balance and employee well-being. According to the study, having the option to work remotely promotes more independence, which raises job satisfaction levels.

overall. However, the organization's capacity to sustain efficient support and communication is crucial to the success of such models.

Gajendran and Harrison's (2020) study investigated the productivity results linked to hybrid work patterns. They came to the conclusion that workers in hybrid environments reported higher levels of productivity, mostly as a result of more flexibility and shorter commutes. Employees are better able to handle their personal obligations in this flexible work environment, which improves their concentration at work. But according to the experts, hybrid models operate best when they are backed by a robust technology infrastructure and management- established expectations that are explicit and help to maintain performance standards in a variety of work settings.

The difficulties faced by workers in hybrid work arrangements were investigated in a study conducted by Raghuram et al. (2020). They discovered obstacles that can have a detrimental impact on employee engagement, such as loneliness and challenges with teamwork. In order to overcome these obstacles, the study underlined the value of frequent check-ins and team-building exercises. The detrimental effects of hybrid work models on employee morale and cohesiveness were also found to be mitigated by organizational initiatives to improve communication and foster a sense of community in virtual settings.

Employee retention rates are greatly impacted by hybrid work arrangements, according to a study by Choudhury et al. (2020). Since it enabled them to better combine work and home life, employees with flexible work arrangements were shown to be more committed to their organizations. Businesses using hybrid models should modify their policies to meet the needs of their diverse workforce, according to the report, so that personal and professional commitments are fulfilled without sacrificing output.

Many academics have written a great deal about how technology may support hybrid work. According to a study by Agarwal et al. (2021), businesses that offer state-of-the-art technology to facilitate smooth communication and teamwork have a higher chance of success with their hybrid work initiatives. In order to facilitate seamless workflow management and preserve organizational culture in a distributed work.

Environment, the study discovered that solutions such as video conferencing, project management software, and instant messaging platforms aid in bridging the gap

between remote and in-office workers. The framework for adopting a hybrid work paradigm is not universal because it differs based on the corporate culture and type of work. Because of the nature of their job, which is frequently done remotely, IT companies like TCS may find it easier to adopt hybrid work models, per a study by Citera and Curry (2020).

These models' effectiveness is still contingent on a number of variables, including staff preparedness, leadership philosophies, and the accessibility of the required infrastructure. According to the report, the effective implementation of these models depends on a clear hybrid policy and steady organizational support.

METHODOLOGY

The purpose of this study's research technique is to assess the variables affecting Tata Consultancy Services' (TCS) in Nagpur's adoption of hybrid work models. To give a thorough study, a mixed-methods approach was chosen, including both quantitative and qualitative data. This method makes it possible to fully comprehend how employees feel, think, and experience hybrid work. By using both approaches, the results are triangulated, improving the validity and dependability of the study findings.

One hundred employees from different departments at TCS, Nagpur, who now work in hybrid arrangements, will participate in the study. To guarantee that individuals from all departments, positions, and experience levels are included, a stratified random sample technique will be employed. By using this method, a more representative sample can be obtained, guaranteeing that the results accurately represent the range of viewpoints present in the company. A sample size of 100 participants is adequate to preserve a manageable scope for qualitative insights while achieving statistical significance for the quantitative analysis.

In order to quantify important characteristics like work-life balance, job satisfaction, productivity, and organizational support, a structured questionnaire with Likert-scale questions will be created for the quantitative component. To ensure convenience and ease of access, the participants will receive the questionnaire electronically. To find trends, correlations, and important factors influencing TCS, Nagpur's adoption of the hybrid work paradigm, the data will be analysed using statistical software, including descriptive statistics and inferential tests.

A subset of 20 participants will participate in semi-structured interviews to collect qualitative data for the survey. Deeper investigation of the experiences, difficulties, and advantages of hybrid work will be possible thanks to these interviews. Open-ended questions will be the main focus of the interview guide in order to motivate participants to elaborate on their ideas. To locate important themes and insights that support the quantitative findings, the qualitative data will be transcribed and subjected to thematic analysis.

A pilot test of the survey questionnaire will be carried out with a limited group of employees in order to guarantee the validity and reliability of the research instruments. The survey's clarity and applicability will be improved with input from this pilot study. Additionally, the semi-structured interview questions will be pre-tested to make sure they are understandable to participants and capture the desired insights.

A key component of the research process is ethical issues. Prior to data collection, participants will be briefed about the study's objectives and their consent will be sought. Throughout the survey, confidentiality and anonymity will be upheld to prevent the disclosure of specific responses. Additionally, participants will be made aware of their freedom to leave the study at any moment and without repercussions.

The process of analysing data will involve several steps. First, the quantitative data will be cleaned and processed to address any missing values or outliers. Descriptive statistics will be used to compile the data, and The hypotheses will be tested using inferential analysis. After the qualitative data has been coded and categorized, themes will be found. The combined findings will give a comprehensive picture of the elements affecting TCS, Nagpur's adoption of hybrid work models and will be helpful to companies looking to introduce or improve hybrid work practices.

OPPORTUNITIES & CHALLENGES

Organizations and people can benefit from a variety of opportunities presented by the adoption of hybrid work models. Improved work-life balance is one of the main advantages. Employees are better able to balance their personal and professional obligations when they have the option to work from home or the office. Employees that have more flexibility feel like they have more control over their schedule, which frequently results in higher job satisfaction. Employee retention is likely to improve for

companies that use hybrid models since employees are more likely to stick with companies that provide flexible scheduling.

The possibility of higher productivity is an opportunity. As emphasized in previous research, many employees claim improved productivity levels when working from home due to less interruptions, more comfortable locations, and better control over their work schedules. Employees can customize their workspaces to meet their needs in hybrid work arrangements, which improves concentration and productivity. Because they are more driven and involved in their work, employees may perform better overall for firms. Businesses can also save a lot of money by using the hybrid work style. Businesses can cut spending for office space, utilities, and other overhead when fewer workers work in the office full- time.

For companies with sizable workforces, such as TCS, where flexible work arrangements can maximize office space use, this can be very advantageous. Employees can also save money on commuting expenses, which will improve their overall financial health and lessen the stress that comes with lengthy commutes.

There are drawbacks to the mixed work approach as well. Making sure there is effective communication and teamwork is one of the biggest concerns. Employees may feel alienated from their colleagues in a hybrid setting, which could result in a breakdown in communication. Employees that are dispersed across various regions or time zones may experience misunderstandings or reaction time delays. To close this gap and preserve a harmonious team environment, firms must put strong communication tools and strategies into place.

Maintaining corporate culture in a hybrid setting is difficult. Some workers can benefit greatly from flexible work arrangements, but others might experience loneliness or a sense of disengagement from the company's goals and principles. To maintain employee engagement, organizations must establish virtual places for social interactions, team-building, and frequent check-ins. To guarantee that workers, wherever they may be, feel supported, leadership philosophies may also need to change. To promote inclusion and trust, management may need to make adjustments and provide more training.

Hybrid work paradigms may present infrastructure- related difficulties. Employers need to make investments in dependable platforms and solutions that enable seamless

communication and cooperation between in-person and remote workers. This entails guaranteeing data protection, facilitating a range of devices, and offering safe access to corporate resources. The hybrid work approach can result in inefficiencies, security threats, and lower employee satisfaction if it has a strong technology foundation.

Employee experiences may become unequal as a result of hybrid work practices. Compared to their remote counterparts, employees who work mostly in the office could have more prospects for networking, job promotion, and visibility. Disparities in performance reviews and advancement prospects may result from this. To guarantee that all workers, regardless of where they work, receive fair treatment and equal opportunity for advancement, organizations must be aware of these possible disparities and put fair rules into place.

RESULTS AND DISCUSSION

According to the study's findings, a substantial portion of TCS Nagpur staff members are in favor of the hybrid work style.



Fig. 1 Work-Life Balance

After implementing hybrid work arrangements, almost 75% of the participants said they were happier with their work-life balance shown in Fig 1. This result is in line with earlier studies that show that employee well-being is associated with flexible work hours. One of the most important factors influencing increased job satisfaction in hybrid contexts is the capacity to better balance personal and professional obligations.

According to 68% of workers, working remotely increases productivity since it allows them to work in a more comfortable setting and with less distractions.

Nevertheless, 32% of respondents believed that working from home reduced their productivity, mostly as a result of insufficient home office settings and distractions from the home shown in Fig 2.

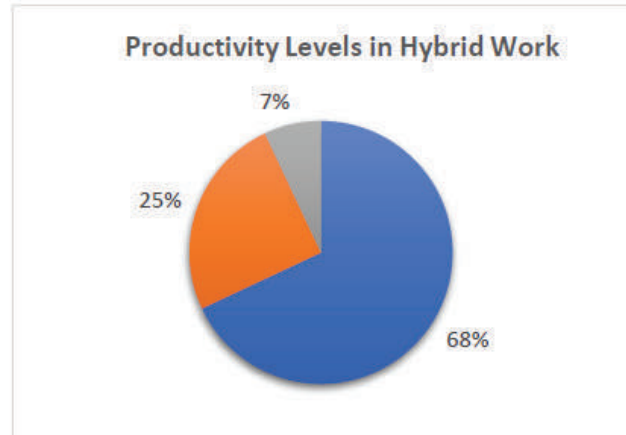


Fig 2 Productivity Levels

This suggests that although hybrid work can increase productivity for a large number of workers, it might not be beneficial for everyone, and those who are having difficulties may need more help or resources.

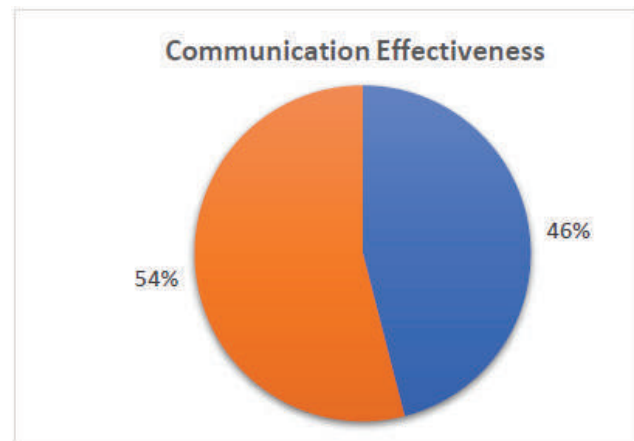


Fig. 3 Communication Effectiveness

Collaboration and communication were found to be the main obstacles in mixed work environments. Concerns regarding challenges in maintaining communication with their teams, especially when working remotely, were voiced by roughly 54% of respondents. Numerous workers pointed out that online communication frequently lacked the clarity and immediateness of face-to-face conversations. Virtual collaboration technologies, however, were deemed useful by 46% of participants for

sustaining team communication and project advancement shown in Fig. 3. This emphasizes how crucial it is to use the appropriate technology and teach staff members how to use it efficiently in order to achieve the best possible collaboration in a hybrid environment.

Additionally, the study discovered that organizational culture has two sides in hybrid settings. When working remotely, almost 40% of workers reported feeling cut off from the business culture, which may have affected their general involvement and loyalty to the company. On the other hand, 60% of workers said that frequent virtual check-ins and team-building exercises made them feel equally a part of the company's values and mission, regardless of where they worked. These findings imply that although hybrid work may put corporate culture under stress, this problem can be lessened by using efficient communication techniques 55% of workers were worried that remote workers might not be considered for promotions or recognition when it comes to professional growth. Those who worked from home most of the time had a stronger awareness of this. But according to 45% of workers, the hybrid.

Although the hybrid work paradigm has many advantages, such as increased productivity and work-life balance, it also has drawbacks, especially when it comes to communication, corporate culture, and career advancement.

The study's findings imply that in order to overcome these obstacles, firms need to offer sufficient assistance, such as technology tools, effective communication channels, and fair career growth chances. Since their success was evaluated on the basis of outcomes rather than in-person presence, addressing these elements had no detrimental effects on their professional development. This emphasizes how important it is for businesses to make sure that performance reviews in hybrid models are impartial and unaffected by the way that work is done.

CONCLUSIONS

The study's conclusions highlight how hybrid work models are becoming more and more significant in today's business environment. Because of its beneficial effects on work-life balance, TCS Nagpur employees have made it apparent that they Favor hybrid work. It is clear that the flexibility provided by the hybrid model has a major impact on staff retention and well-being, since 75% of respondents reported increased job satisfaction. Organizational loyalty

and employee engagement are expected to improve over time for businesses that adopt such approaches.

The hybrid model also exhibits a great deal of promise in terms of productivity. When working from home, the majority of participants (68%) said they were more productive. This increase in productivity seems to be primarily driven by the capacity to customize work surroundings and the decrease in workplace distractions. However, there are still issues for a portion of workers who deal with insufficient setups or distractions at home. This implies that offering tools and advice for efficient home office configurations could increase output even further.

The hybrid model revealed that communication and teamwork were the main problems. Even with the use of digital technologies, more than half of the staff (54%) found it difficult to keep teams communicating consistently. This emphasizes how important it is for businesses to make investments in improved collaboration tools and provide staff with the necessary training. In hybrid arrangements, maintaining open and flexible communication.

Concerns regarding company culture and career advancement were also raised by the study. Although 55% of workers thought that working remotely may limit their chances for promotion, 45% thought that their performance was evaluated equally regardless of where they worked. These observations highlight how crucial it is to keep impartial performance review procedures in place to guarantee equal chances for all workers, regardless of their work arrangements. A key component of the hybrid work model's support is technological infrastructure.

Employees and the company stand to gain a great deal from TCS Nagpur's adoption of the hybrid work paradigm. To make sure the model fulfils its promises, it is imperative to address issues with communication, career growth, and technology infrastructure. TCS can foster an environment where people and the business may prosper by further modifying and improving the hybrid work approach.

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Perception and Assimilation of Faculty Members in Acquiring New Skills: A Study in Educational Institutes

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ABSTRACT

This study examines faculty member's perceptions of acquiring new skills, factors influencing skill assimilation, and strategies adopted by educational institutes for faculty member's development. Surveying a group of faculty members, the findings reveal a strong willingness to learn new skills, with many actively seeking professional growth opportunities. Key factors influencing skill acquisition include management support, availability of resources, peer collaboration, and personal motivation, while time constraints pose challenges. The study shows that institutes primarily use online learning platforms and workshops for faculty member's development, with high levels of satisfaction. The research suggests that enhancing strategies through peer-learning and mentoring could further improve faculty member's development.

KEYWORDS : *Faculty member's development, Skill acquisition, Perception and assimilation.*

INTRODUCTION

Faculty members serve as the pillars supporting the entire edifice of education, working tirelessly for student development. It is globally acknowledged that proficient, competent, and well-equipped faculty members with a positive attitude toward teaching can imbue their students with all the essential traits. The perception and assimilation of new skills by faculty members have become integral to the teaching system.

Faculty members are the role models for every student. The increasingly challenging environments, high-stakes testing, and institute accountability are compelling administrators to concentrate on the crucial link between faculty members competency and student achievement. In today's scenario, greater emphasis is placed on the personalities of faculty members and their self-beliefs.

This renewed emphasis underscores a timeless certainty for students to achieve high standards, nothing less can be expected of their faculty members.

Perception, derived from the term "percept," involves processes of organizing and interpreting stimuli to make sense of our environment. Sensory receptors detect stimuli, transmitting them to the central nervous system through transduction. Perception depends on how one interprets sensory stimuli, following sensation. Assimilation is the process of absorbing and understanding new information or experiences based on existing consciousness.

LITERATURE REVIEW

A study titled "Self-Perceived Instructional Competence, Self-Efficacy, and Burnout During the COVID-19 Pandemic" examined the experiences of Italian school teachers and found that the ongoing changes in education, coupled with the challenges brought by the pandemic, have led to increased burnout among educators. This situation has created new demands in the educational landscape, requiring teachers to adapt to evolving instructional requirements. [1]. Impact of Two-year B.ed Programme on student teachers teaching self-efficacy:

Prayagraj & Varanasi City find that the 2 years B.ed Programme is a good initiative to develop a strong belief, self- assurance, and a positive outlook toward the teaching profession among student teachers of both Central and state universities [2]. Teachers' Perception on Students' Learning Style and Their Teaching: Indonesia concluded that Understanding the concept of students' learning styles can make the task of teachers easier to enhance their teaching quality with great skills and attitudes. It can make teachers and students' interaction more effective in and out of the classroom [3]. A study conducted in Italy explored the connection between teachers' self- efficacy, personal values, and teaching motivation. The findings revealed that conservation values had a positive impact on self- efficacy, regardless of the teachers' motivation type or level. [4]. Studying teachers self-efficacy and experience while empowering technology used through personalized professional learning: USA as per their study the teachers' perceptions of their ability to use technology tools and their self- efficacy in using technology in the classroom significantly improved after the training [5]. A study in Germany examined teachers' involvement in professional development related to integrating new technologies in the classroom. The findings indicated that German teachers prefer practical approaches to professional development. Those who actively participate tend to use computers more frequently in their teaching and place a stronger emphasis on developing students' ICT skills. [6]. Relationship of self-efficacy and teacher knowledge for prospective elementary education teachers: US" identified that both academic and experiential learning are crucial for building strong knowledge and high self-efficacy in prospective teachers [7]. Emotional intelligence & self-efficacy of school teachers: Kerala district concluded that Emotional intelligence and self- efficacy have a significant relationship with each other teacher should develop their emotional intelligence that could boost their sense of efficacy because teacher's self-efficacy is linked to student development [8]. Teacher's self- efficacy and student learning: Europe concluded that Teachers' self-efficacy beliefs in their teaching abilities alone do not guarantee effective instruction; they must also possess the necessary knowledge and skills to help students achieve the desired learning outcomes [9].

RESEARCH METHODOLOGY

Study is based on primary data and the duration of data collection is 2024-2025. The data has been collected from

management educational institute of Nagpur city. For data collection from respondents a self-designed questionnaire method was used, to meet the objectives of the study. Sample size used in this study is 27.

Objective

- To study faculty member's perception of their willingness in learning new skills.
- To assess the key factors influencing faculty member's assimilation in learning new skills.
- To explore the strategies adopted by educational institute for enhancing the faculty member's assimilation in learning new skills.

Hypothesis

H01: There is no significant relationship between faculty member's perception and learning new skills.

H02: There are no significant factors that influence faculty member's assimilation in learning new skills.

H03: Educational institutes are adopting different strategies for supporting faculty members in learning new skills.

DATA INTERPRETATION

Table. 1: Demographic Profile of Respondents

Demographic Factors		No of Respondents	Percentage (%)
Gender	Male	16	59.26
	Female	11	40.74
	Total	27	100.00
Age	20-30	4	14.81
	31-40	20	74.07
	41-50	2	7.41
	51-60	1	3.70
	61 and above	0	0.00
	Total	27	100.00
Designation	Professor	4	14.81
	Associate Professor	9	33.33
	Assistant Professor	14	51.85
	Other	0	0.00
	Total	27	100.00

Teaching Experience	Less than 5 yrs	8	29.63
	5-10 yrs	12	44.44
	11-15 yrs	6	22.22
	16-20 yrs	1	3.70
	Total	27	100.00

The demographic data indicates that the respondents are predominantly male (59.26%), with a significant majority (74.07%) aged between 31-40 years, suggesting a mid-career group. In terms of designation, most participants are Assistant Professors (51.85%), followed by Associate Professors (33.33%) and Professors (14.81%), reflecting a diverse academic hierarchy. Regarding teaching experience, the majority (44.44%) have 5-10 years of experience, followed by 29.63% with less than 5 years, and 22.22% with 11-15 years, while only 3.70% have 16-20 years. This data highlights a workforce composed primarily of early to mid-career educators with varying levels of seniority and academic roles.

Table 2: Perception of Willingness in Acquiring New Skills

Perception of Willingness in Acquiring New Skills	SD	DA	N	A	SA
I am willing to acquire new skills to enhance my teaching abilities.	0	1	3	7	16
I believe that learning new skills is essential for professional growth.	0	1	1	1	24
I actively seek opportunities to learn new teaching methodologies and technologies	1	2	1	10	13
I feel confident in my ability to adapt to changes in the education landscape through acquiring new skills.	0	1	2	5	19
I perceive acquiring new skills as a valuable investment in my career.	0	1	1	3	22

The data shows a strong commitment to skill acquisition among respondents, with 85.19%, willing to acquire new skills for professional growth with 92.59% and 85.18% to learn new teaching methodologies and technology. 88.89% feel confident in adapting to changes in education through skill development, and 92.59% strongly agree that acquiring new skills is a valuable career investment, highlighting a shared belief in lifelong learning.

Hypothesis Support

The analysis didn't support the hypothesis (H01): "There is no significant relationship between faculty member's perception and learning new skills." From the data

analysis we observed that the majority of respondents have a positive perception toward learning new skills. Since a large majority positively perceives skill acquisition, H01 is rejected. There is a significant relationship between faculty member's perception and their willingness to learn new skills.

Table. 3: Key Factors Influencing Teachers' Assimilation in Learning New Skills

Key Factors	SN	NG	N	P	SP
Support from Management	0	0	5	9	13
Availability of Resources (e.g., training programs, workshops, materials)	1	1	3	7	15
Time Constraints	1	2	7	10	7
Peer Support and Collaboration	0	1	2	12	12
Personal Motivation and Interest	0	1	3	8	15

The data shows that faculty member's generally have positive views on factors influencing assimilation. Support from management, availability of resources, peer support, and personal motivation are all rated positively, with the majority of respondents expressing favorable opinions. However, time constraints received more neutral feedback, indicating some challenges in this area that may affect strategies.

Hypothesis Support

The analysis didn't support the hypothesis (H02): "There are no significant factors that influence faculty member's assimilation in learning new skills." We observed that most key factors influencing skill assimilation (like management support, resource availability, peer support, and personal motivation) received positive feedback. Given the overall positive responses to key factors, H02 is rejected. There is a significant factor influencing faculty member's assimilation in learning new skills.

Strategies Adopted by Management Institutes

The management institutes primarily adopt online learning platforms and resources (52%) and regular training programs or workshops (38%) as their key strategies for employee development. However, less emphasis is placed on encouraging participation in conferences (4.8%), while strategies like peer-learning communities, mentoring programs, and offering incentives for skill

acquisition are entirely absent. This highlights a reliance on traditional and digital learning methods, with minimal focus on collaborative or motivational approaches. Exploring underutilized strategies could enhance the overall effectiveness of their learning and development initiatives.

Satisfaction with Strategies Adopted by Management Institutes

The data reveals an overwhelmingly positive reception to the strategies implemented by management institutes. Among the 27 respondents, a notable 22.2% reported being highly satisfied, while a majority 55.6% expressed satisfaction, showcasing strong approval. Interestingly, 22.2% remained neutral, indicating a lack of strong sentiment either positive or negative toward the strategies. Remarkably, there were no reports of dissatisfaction or high dissatisfaction, reflecting that the strategies are effectively addressing core expectations. However, the neutral responses hint at untapped potential to refine and enhance these strategies, transforming lukewarm opinions into enthusiastic endorsement.

Hypothesis Support

The analysis partially accepted the hypothesis (H03): "Educational institutes are adopting different strategies for supporting faculty members in learning new skills. "From the analysis of strategies adopted by management institutes, it's clear that the institutes are taking steps to support skill development. However, collaborative strategies like peer-learning communities or mentoring programs are missing. The data suggests that institutes are making efforts to adopt strategies, but these efforts are incomplete and could be enhanced. Thus, H03 is partially accepted.

CONCLUSION

The study highlights faculty members' strong commitment to acquiring new skills for professional growth, with most expressing a willingness to enhance their teaching abilities. Key factors influencing skill assimilation include personal motivation, institutional support, and available resources, though time constraints remain a challenge.

Management institutes primarily rely on online platforms and workshops for faculty member's development, which are generally well-received, though there is room for improvement through more collaborative strategies

like peer-learning and mentoring programs. Overall, the findings suggest that while current strategies are effective, there is potential to further engage faculty members and enhance skill development through more diverse and innovative approaches.

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The Psychological Appeal of Free Promotions: A Study of Impulse Buying Among Gen Z Students

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ABSTRACT

Among Gen Z students, impulsive purchasing, which is fuelled by psychological triggers, has grown significantly, especially in the age of digital commerce and targeted marketing. The psychological attraction of advertising tactics and their impact on this demographic's impulsive purchasing behaviour are examined in this study. Important triggers such as perceived scarcity, FOMO, and the emotional reward of discounts and special offers, drawing on theories of consumer psychology and behavioural economics.

The study uses a mixed-method approach to examine data from focus groups, surveys, and behavioural experiments with Gen Z students between the ages of 11 and 26. Results show that social media endorsements, tailored discounts, and time-limited promotions greatly increase the chance of impulsive purchases. The study also emphasises how both external factors, like peer pressure and exposure to influencer marketing, and personal characteristics, like self-control and financial literacy, can have moderating impacts.

In addition, it emphasises how crucial it is to raise young customers' financial literacy in order to lessen the possible negative effects of impulsive spending. By connecting marketing tactics with customer behaviour, this study advances our knowledge of how promotions influence decisions to buy in the digital era.

KEYWORDS : *Impulse buying; Gen Z students; Consumer psychology; Fear of missing out (FOMO); Digital marketing; Social media influence; Financial literacy.*

INTRODUCTION

Impulse buying has surged in the digital age due to aggressive marketing tactics on online shopping platforms. Among these, free promotions like “Buy One Get One Free,” free shipping, and free samples effectively trigger urgency, perceived value, and emotional satisfaction. This study examines how such promotions influence the purchasing behaviour of Gen Z students, a tech-savvy and digital-native demographic known for social media engagement and preference for instant gratification. Born between 1997 and 2012, Gen Z represents a significant consumer segment, highly susceptible to marketing strategies that exploit psychological triggers like scarcity, FOMO, and perceived savings. Free promotions, amplified through e-commerce platforms, social media, and influencer marketing, shape their purchasing habits. Algorithms personalize ads based

on browsing history, while influencers enhance credibility, driving impulsive purchases.

Despite their appeal, free promotions affect individuals differently. Financial literacy, self-control, and social influences determine consumer responses. While financially disciplined students may resist such offers, others with lower financial awareness may perceive them as money-saving opportunities, even if unnecessary. Cultural norms and peer recommendations further shape these behaviours. This study explores the psychological mechanisms behind the allure of free promotions and their impact on Gen Z students' buying decisions. By identifying key triggers and digital influences, the findings provide valuable insights for marketers to refine strategies and for educators to promote financial literacy. Understanding these dynamics is essential in an era dominated by digital marketing, ensuring a balance between effective promotions and responsible consumer behaviour.

LITERATURE REVIEW

Impulse buying is driven by both emotional and cognitive factors (Verplanken & Herabadi, 2001)[14]. External triggers like promotions, discounts, and advertisements create urgency and increase perceived value, leading to impulsive purchases (Hausman, 2000) [6]. Excitement, happiness, and even guilt often accompany these decisions (Kacen & Lee, 2002) [7]. Among promotional tactics, “free” offers generate a stronger emotional appeal than standard discounts, heightening the likelihood of impulse buying (Chandon et al., 2000) [1]. They prefer personalized, fast, and convenient purchasing experiences and frequently engage with digital media, especially social platforms (Williams et al., 2012) [15]. Studies indicate that Gen Z actively shops online, relying on mobile apps and social networks for purchases (Pereira et al., 2021) [11].

Their inclination toward instant gratification makes them particularly susceptible to promotions offering immediate rewards (Williams & Page, 2011) [15]. Influencer marketing and social media play crucial roles in shaping Gen Z’s buying behaviour. Influencers significantly impact their purchasing decisions, particularly when they align with their values and interests (Djafarova & Trofimenko, 2019) [4]. The scarcity effect also contributes to impulsive buying limited-time or low-stock promotions create urgency, prompting quick purchases (Cialdini, 2009) [3]. Similarly, the “free effect” makes consumers assign higher value to no-cost items, increasing their likelihood of buying unnecessary products (Shampanier et al., 2007) [13].

FOMO (fear of missing out) further amplifies the effectiveness of free promotions. It triggers anxiety and regret over missing a deal, encouraging impulsive purchases (Przybylski et al., 2013) [12]. Consumers view influencers as authentic and relatable, which increases engagement with promotions (Freberg et al., 2011; Lim et al., 2020) [5,10]. Gen Z students, especially those with limited financial literacy, may be more vulnerable to free promotions (Lusardi & Mitchell, 2014) [10]. Financially unaware consumers often perceive such deals as substantial savings, even when purchases are unnecessary (Choi et al., 2011 [2]. Peer influence and cultural trends further enhance the appeal of promotions, particularly when disseminated through social media (Leibenstein, 1950) [8].

RESEARCH METHODOLOGY

Research design to examine factors influencing impulsive purchases related to free promotions. Targeting Gen Z students (aged 11-26) from educational institutions in South Pune, a stratified random sampling method ensures demographic diversity. Data collection includes an online survey with closed-ended and Likert scale items, supplemented by semi-structured interviews with 192 respondents. Key variables include free promotions, psychological triggers, and social media influence, with impulse buying behaviour as the dependent variable. Data analysis will use Jamovi software, applying descriptive and inferential methods such as Confirmatory Factor Analysis, regression, and correlation analyses.

OBJECTIVE

Identify Key Psychological Triggers that make free promotions appealing to Gen Z consumers

Understand the frequency and circumstances under which Gen Z students engage in impulse buying

Evaluate the Role of Digital Platforms on Gen Z’s shopping decisions.

Assess Individual and Contextual Factors in moderating the relationship between promotions and impulse buying.

HYPOTHESIS

H0: Psychological triggers do not significantly influence the appeal of free promotions among Gen Z consumers.

H1: Psychological triggers significantly increase the appeal of free promotions among Gen Z consumers.

H0: There is no significant difference in the frequency of impulse buying behaviour among Gen Z students

H2: There is a significant difference in the frequency of impulse buying behaviour among Gen Z students

H0: Social media platforms and e-commerce websites do not significantly influence impulse buying among Gen Z students.

H3: Social media platforms and e-commerce websites significantly increase the likelihood of impulse buying among Gen Z students

H0: Contextual factors, including peer influence and social media trends, do not significantly affect the relationship between free promotions and impulse buying among Gen Z students.

H4: Contextual factors, including peer influence and social media trends, significantly enhance the effect of promotions on impulse buying among Gen Z students.

RESULTS AND DISCUSSIONS

Table 1 Demographical

	Level	Count	Total	Proportion	p
Age	21-25	150	192	0.781	<.001
	26 and above	42	192	0.219	<.001
Gender	Female	82	192	0.427	0.051
	Male	110	192	0.573	0.051
Location	Rural	54	192	0.281	<.001
	Semi-urban	22	192	0.115	<.001
	Urban	116	192	0.604	0.005
Current Occupation	Full-time employee	58	192	0.302	<.001
	Part-time employee and student	32	192	0.167	<.001
	Student	102	192	0.531	0.427
Spend on shopping monthly	Less than ₹1000	74	192	0.385	0.002
	More than ₹5000	24	192	0.125	<.001
	₹1000–₹3000	62	192	0.323	<.001
	₹3000–₹5000	32	192	0.167	<.001

Interpretation

In terms of age, the majority of participants (78.1%) are between 21–25 years, significantly higher than the expected proportion of 50% ($p < .001$). Gender distribution is nearly balanced, with females making up 42.7% and males 57.3%, neither significantly different from the 50% threshold ($p = 0.051$). Regarding location, 60.4% of respondents reside in urban areas, a significantly greater proportion than 50% ($p = 0.005$). Occupationally, students constitute the largest group at 53.1%, which is not significantly different from 50% ($p = 0.427$). In terms of monthly shopping expenditure, most respondents spend less than ₹1000 (38.5%, $p = 0.002$) or ₹1000–₹3000 (32.3%, $p < .001$). These findings highlight significant patterns in age, location, and spending behaviours, with a notable representation of urban, young, and student respondents, while gender distribution and student status remain near-equal to expectations. Hence alternate hypothesis that a

significant difference in the frequency of impulse buying behaviour among Gen Z students is proved.

Table 2 Factor Loadings

Indicator	Estimate	SE	Z	p
Price discount	1.059	0.0894	11.85	<.001
Free promotions	1.041	0.0836	12.45	<.001
Product reviews and ratings	1.094	0.0832	13.14	<.001
Recommendations from friends/family	1.011	0.0793	12.74	<.001
Social media influencers	0.522	0.094	5.55	<.001
Ease of shopping experience (e.g., user-friendly website or app)	1.07	0.0767	13.96	<.001
Brand reputation and trust	1.157	0.0818	14.15	<.001

Interpretation

All estimates have significant p-values ($p < .001$), indicating strong associations with the factor. The indicator Brand reputation and trust has the highest factor loading (1.157), suggesting it plays the most critical role in shaping shopping decisions. This is closely followed by Ease of shopping experience (e.g., user-friendly website or app) (1.070), Product reviews and ratings (1.094). Overall, the findings emphasize the importance of brand reputation, shopping convenience, and trusted sources of information in influencing shopping decisions, while social media influencers have a relatively moderate impact.

Table 3 Psychological Triggers of Promotions

	Level	Count	Total	Proportion	p
Free promotions affect likelihood of purchase	Moderately				
	Not at all	72	192	0.375	<.001
	Slightly	30	192	0.156	<.001
	Strongly	44	192	0.229	<.001
Very Strongly		10	192	0.188	<.001
				0.052	<.001
Limited-time offers increase urgency to buy	No	72	192	0.375	<.001
	Yes	120	192	0.625	<.001

Regret purchasing items part of a free promotion	Always	6	26	192	0.031	0.135	<.001
	Never	14	60	192	0.073	0.313	<.001
	Often		86	192		0.448	<.001
	Rarely			192			<.001
	Sometimes			192			0.17

Interpretation

The psychological impact of promotional strategies on consumer behaviour. Free promotions, moderately influence the purchase likelihood for the majority of respondents (37.5%, $p<.001$), Limited-time offers were found to be highly effective in creating urgency, with 62.5% of respondents reporting increased urgency ($p<.001$). Regarding regret associated with free promotions, 44.8% of respondents sometimes regretted their purchases ($p=0.170$). Overall, the findings suggest that promotional strategies like free offers and limited-time deals effectively influence consumer behaviour, driving urgency and purchase decisions with minimal long-term regret, making them valuable tools for marketers. Hence alternative hypothesis Psychological triggers significantly increase the appeal of free promotions among Gen Z students is proved.

Table 4 Role of Digital Platforms

	Level	Count	Total	Proportion	P
Influential of social media advertisements	Extr	4	92	1	0.02
	eme	6	1	0.33	01
	influen	4	92	3	<.0
	ce	2	1	0.12	01
	Moderate	4	92	5	<.0
	Not at all	7	1	0.36	01
	Slightly	0	92	5	<.0
	Very	3	1	0.15	01
	Strong	0	92	6	
	Alw	6	1	0.03	
Purchases through links or recommendations	ays	2	1	0.125	<.0
	Never	4	92	0.08	01
	Often	6	1	0.35	<.001
	Rarely	8	1	0.40	<.001
	Sometimes	7	1	0.011	0.011

Interpretation

The role of digital platforms, specifically social media, in influencing shopping decisions and purchases driven by advertisements or influencer recommendations. Social media advertisements were reported to have a slight (36.5%) or moderate (33.3%) influence on most consumers. Regarding purchases through links or recommendations from social media influencers, respondents engaged with these sometimes (40.6%) or rarely (35.4%) ($p<.001$). Overall, the findings suggest that while digital platforms, including social media advertisements and influencer recommendations, play a role in shaping shopping decisions, their influence tends to be moderate or occasional rather than overwhelming. This indicates the potential for marketers to optimize their digital strategies to better capture consumer interest and engagement. Hence alternative hypothesis Social media platforms and e-commerce websites significantly increase the likelihood of impulse buying among Gen Z students is proved.

Table 5 Individual and Contextual Factors

	Level	Count	Total	Proportion	p
Self-control when shopping	High	44	28	192	0.229
	Low	92	12	192	0.146
	Moderate	16	192	0.063	<.001
	Very high		192	0.614	<.001
	Very low		192	<.001	<.001
Financially literate	High	34	34	192	0.177
	Low	98	12	192	0.177
	Moderate	14	192	0.063	<.001
	Very high		192	0.829	<.001
	Very low		192	<.001	<.001
Peers or friends influence	Always	4	12	192	0.021
	Never	28	54	192	0.063
	Often	94	192	0.281	<.001
	Rarely		192	0.49	<.001
	Sometimes		192	0.829	<.001
Financial situation impact impulse buying	Moderately	86	16	192	0.448
	Not at all	42	40	192	0.083
	Slightly	8	192	0.208	0.17
	Strongly		192	0.042	<.001
	Very Strongly		192	<.001	<.001

Interpretation

The analysis explores self-control, financial literacy, peer influence, and the impact of financial situations on shopping behaviours. Most respondents perceived their self-control as moderate (47.9%), indicating a balanced approach to shopping. Similarly, financial literacy was predominantly rated as moderate (51%). Peer influence

on shopping decisions was reported as occasional by 49% of respondents. Financial situations moderately impacted impulse buying for 44.8% of respondents. Overall, the findings highlight that while most individuals exhibit moderate self-control and financial literacy, social and financial factors occasionally influence their shopping behaviours. These insights emphasise the importance of addressing individual variability through tailored financial education and marketing strategies.

Table 6 Factors influencing the appeal of free promotions, unplanned purchases

	LEVEL	COUNT	TOTAL	PROPOR-TION	P
FREE PROMOTIONS SO APPEALING	OTHER	30	192	0.156	<.001
	EXCITEMENT OF "FREE."	62	192	0.323	<.001
	MORE VALUE FOR MONEY	26	192	0.135	<.001
	ADVERTISEMENTS PROMOTING THE DEAL.	10	192	0.052	<.001
	URGENCY TO ACT QUICK	64	192	0.333	<.001
UNPLANNED PURCHASE	QUALIFY FOR A "BUY ONE GET ONE FREE"	44	192	0.229	<.001
	ITEMS AVAIL OF FREE SHIPPING	44	192	0.229	<.001
	FLASH SALE WITH FREE GIVEAWAYS	10	192	0.052	<.001
	FREE SAMPLE	58	192	0.302	<.001
	OTHER	36	192	0.188	<.001

Interpretation

Free promotions appeal to consumers by creating excitement (32.3%) and urgency (33.3%). These promotions often lead to unplanned purchases, with 22.9% buying to qualify for “Buy One Get One Free” deals or free shipping, and 30.2% purchasing unexpected items due to free samples. For marketers targeting Gen Z, key strategies include fostering exclusivity and urgency (26%), offering personalized promotions (21.9%), and leveraging influencers (22.9%). Managing impulse buying strategies include setting a budget (25%), improving financial literacy (21.9%), and avoiding online browsing during sales (18.8%). The study highlights how free promotions influence purchasing behaviour and provides actionable

insights for both marketers and consumers. Contextual factors, such as peer influence and social media trends, significantly enhance the impact of promotions on Gen Z’s impulse buying, supporting the alternate hypothesis.

Results presented in this section, be described in the form of text and highlight the most important points. Figures, tables, and equations can be used for the purposes of easy understanding and clarity. Reproduction of data in form of both figures and tables without any proper reason should be avoided. While presenting the results achieved in the present research work can be compared with other investigators, but provide the source [].

The purpose of the discussion part is to explain how the results and why they are important. Compare and justify how your results better or useful than with the results of other investigators under similar conditions. For example, 80% of copper metal was recovered in the present research work using ABC material in a time period of 90 min. However, John Kit has achieved only 70% recovery using the same ABC material in 80 min., [], 10% higher recovery with an increase of 10 min. contact time.

Trust and approval are basic to the effective arrangement of generative man-made intelligence in medication and medical services. ChatGPT’s reactions have uncovered a wide and, all the more fundamentally, capricious scope of value and veracity. This ‘unusualness’ is the primary boundary to reception achievement, since we don’t have any idea when it will return a clever response and when its responses will be off-base or misdirecting, or at the end of the day, when too trust generative simulated intelligence and when not to trust it, particularly when the client isn’t adequately able to evaluate the quality (exactness and culmination) of a given reaction [6]. This idea of trust raises comparable issues like clinical wellbeing and unwavering quality. Until we have an appropriately restoratively prepared and approved generative computer based intelligence (ChatGPT, for instance, isn’t particularly medicinally prepared), there will constantly be interconnected issues of trust, security, and dependability that forestall any huge clinical use of it. We characterize “therapeutically prepared” as a model that has been explicitly and broadly prepared using a corpus of value proof based clinical writing that properly cover a specific clinical area of specialization.

CONCLUSIONS

This study explores factors influencing consumer shopping

behaviour, focusing on demographics, psychology, and promotional strategies. Brand reputation, ease of shopping, and product reviews are the most impactful factors, with brand reputation being the strongest. Financial incentives, such as price discounts and free promotions, significantly drive purchases, while social media influencers have a moderate influence. Limited-time free promotions create urgency and boost sales but result in minimal long-term regret. The study also examines self-control, financial literacy, and peer influence. While most consumers report moderate self-control and financial knowledge, these factors occasionally impact shopping decisions. Impulse buying, shaped by social and financial circumstances, is particularly prevalent among younger consumers.

For marketers, free promotions that generate excitement and urgency are highly effective, especially for Gen Z. Popular promotional content includes discount codes, flash sales, and free giveaways, with discount codes being the most attractive. Consumers primarily shop online or in physical stores, and free promotions evoke happiness and satisfaction. To manage impulse buying, strategies such as budgeting, understanding marketing tactics, and delaying purchase decisions are recommended. Overall, the findings highlight the importance of aligning marketing strategies with consumer preferences while promoting financial literacy and responsible spending.

FUTURE RESEARCH DIRECTION

Future research could explore several key areas to further understand Gen Z's impulse buying behaviour. Longitudinal studies could track how impulse buying evolves as Gen Z transitions into adulthood. Cross-cultural research would offer insights into regional differences, while investigating sustainable promotions could reveal how eco-conscious behaviours impact impulse buying. Financial literacy interventions could be explored to control impulsive buying, and behavioural segmentation would help marketers design more personalized campaigns. These avenues will provide deeper insights into Gen Z's purchasing patterns and offer actionable marketing strategies.

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Strategic Approaches to Customer Retention in India's Online Food Industry – Trends Across Tier-II Cities

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ABSTRACT

Customer retention plays a crucial role in the online food delivery industry, particularly in India, where platforms like Zomato and Swiggy dominate the market. This paper explores the strategic approaches employed by these platforms to retain customers across Tier-I and Tier-II cities. By analyzing secondary data from industry reports, case studies, and academic research, this study identifies the key customer retention strategies, such as loyalty programs, personalized marketing, and pricing strategies, and their varying effectiveness in different market tiers. While Tier-I cities exhibit higher engagement and spending habits, Tier-II cities present unique challenges due to price sensitivity and logistical constraints. The paper provides actionable recommendations for improving customer retention in Tier-II cities by adapting strategies that reflect regional differences in customer behavior.

KEYWORDS : *Customer retention, Online food industry, Zomato, Swiggy, Tier-I cities, Tier-II cities, Loyalty programs, Personalized marketing, Pricing strategies, Quality of service.*

INTRODUCTION

Customer retention refers to a business's ability to retain its existing customers over time, rather than focusing solely on acquiring new ones. In the context of India's online food industry, customer retention is crucial for ensuring long-term profitability and brand loyalty. The increasing number of digital platforms and food delivery services in India has led to heightened competition in the sector, with Zomato and Swiggy being the two dominant players. These platforms rely heavily on customer retention strategies to maintain and grow their user base. The significance of customer retention lies in its cost-effectiveness, as acquiring new customers can be far more expensive than retaining existing ones. The focus of this study is to analyze the customer retention strategies of Zomato and Swiggy, with particular attention

to the evolving trends in Tier-II cities, compared to their operations in Tier-I cities.

PROBLEM STATEMENT

Customer retention is a critical challenge in India's online food delivery industry, where platforms like Zomato and Swiggy dominate. While Tier-I cities benefit from established customer engagement and loyalty strategies, Tier-II cities present unique hurdles such as heightened price sensitivity, logistical issues, and varying customer expectations. These challenges necessitate the adaptation of retention strategies to suit regional preferences, as the inability to retain customers in these markets can limit growth potential and profitability. This research aims to address these gaps by exploring retention strategies tailored to the dynamics of Tier-II cities.

LITERATURE REVIEW

The literature on customer retention strategies in India's online food industry is vast, but key strategies include loyalty programs, personalized marketing, pricing strategies, and the overall quality of service. Loyalty programs, such as Zomato's Gold and Swiggy's Super, provide customers with incentives to continue using the platforms. These programs are designed to increase repeat usage and foster brand loyalty. Personalized marketing, using customer data to tailor promotions, offers, and communication, also plays a vital role in retaining customers. Additionally, competitive pricing strategies, like discount schemes and offers, have proven effective in keeping customers engaged.

Several studies have highlighted the role of service quality, especially in food delivery, where timely deliveries, accurate orders, and responsive customer support are crucial for customer satisfaction and retention. In Tier-I cities, these strategies are well-established, with customers showing a preference for convenience, speed, and variety. However, in Tier-II cities, customer behaviour varies significantly. Research has indicated that price sensitivity is higher in smaller cities, where customers may prioritize affordability over variety or speed.

Zomato Annual Report (2024), the report provides insights into Zomato's decade-long journey, focusing on its strategies for market expansion and customer retention. It emphasizes the company's investment in loyalty programs like Zomato Gold and its efforts to enhance delivery quality. The report also discusses the challenges faced in Tier-II cities, including limited customer engagement and logistical constraints [1].

Swiggy Annual Report (2023), Swiggy's report explores its growth trajectory, highlighting its affordability-focused retention strategies. The document showcases initiatives such as region-specific discounts and enhanced delivery infrastructure. It identifies key challenges in Tier-II cities, particularly in building customer loyalty amidst high price sensitivity [2].

PwC India (2022), this industry report analyzes trends and projections in India's food delivery market. It identifies customer retention as a critical factor for sustained growth and discusses how platforms leverage technology and localized marketing to address regional disparities [3].

Statista (2022), the report provides statistical insights into the market share and performance of Zomato and Swiggy

in India. It underscores the role of customer retention in market dominance and discusses trends in user engagement and loyalty across different city tiers [4].

Premium Pricing Strategy And Customer Retention

– An Analysis, This study examines the relationship between premium pricing strategy and customer retention in international hotels in Kurdistan. A survey of 417 guests confirmed a significant positive association between pricing strategy and retention [5].

E-retail factors for customer activation and retention: An empirical study from Indian e-commerce customers, This study explores factors influencing customer satisfaction and repeat purchase intention in e-commerce. A survey of Indian online shoppers identified service quality, trust, and net benefit as key drivers. Findings highlight the role of utilitarian and hedonistic values in enhancing customer loyalty [6].

High Value Customer Acquisition & Retention Modelling

– A Scalable Data Mashup Approach, This study explores how integrating Mobilewalla's mobile consumer data with an online food delivery company's data enhances customer retention and acquisition. The model identified high-impact customers with 21.41% higher ARPU and optimized 80% of the retention budget. Findings highlight the value of big data in predicting customer behavior and improving business strategies [7].

Reinvestigating Key Factors of Customer Satisfaction Affecting Customer Retention for Fast Food Industry, This study examines key factors influencing customer satisfaction and retention in the Malaysian fast food industry. A survey of 180 customers analyzed product quality, service quality, prices, facility, and emotional factors using SPSS 21. Findings reveal that emotional factors and facility have the strongest impact on satisfaction, ultimately driving customer retention [8].

Role of Customer Retention Equity in Creating and Developing Brand Value, This study develops a customer retention equity scale and examines its impact on brand value in the Indian banking sector. A survey of 500 account holders found that retention strategies significantly enhance brand loyalty, association, and awareness [9].

The Effect of Service and Food Quality on Customer Satisfaction and Hence Customer Retention, This study explores how service and food quality impact customer satisfaction and retention in limited-service restaurants

near universities in Amman, Jordan. A survey of 283 students found that both factors positively influence satisfaction, which mediates the link between service quality and retention [10].

RESEARCH METHODOLOGY

This research employs secondary data analysis, using a range of industry reports, case studies, academic research, and government publications. Secondary data provides a broad understanding of the customer retention strategies used by Zomato and Swiggy in different cities, focusing on trends in Tier-I and Tier-II cities. Parameters for comparison include customer preferences, spending habits, engagement with promotions, and frequency of food orders. This approach ensures a comprehensive view of existing strategies and their effectiveness.

To compare Tier-I and Tier-II cities, this study will rely on publicly available data on user demographics, sales performance, and customer feedback. Reports from organizations like Statista, PwC, and Nielsen, alongside Zomato and Swiggy's own annual reports, will be used to gain insights into regional differences in customer behavior. Additionally, academic literature on regional market dynamics and consumer psychology provides context for interpreting the observed trends. By synthesizing these sources, the methodology ensures a robust framework for understanding customer retention strategies in the online food industry.

To analyze the customer retention strategies employed by online food delivery platforms like Zomato and Swiggy in India's Tier-I and Tier-II cities.

RESEARCH OBJECTIVES

To examine the effectiveness of loyalty programs, personalized marketing, and pricing strategies in retaining customers across different city tiers.

To identify unique challenges faced by food delivery platforms in retaining customers in Tier-II cities, focusing on factors like price sensitivity and logistical constraints.

To provide actionable recommendations for improving customer retention in Tier-II cities by aligning strategies with regional customer behavior.

CUSTOMER RETENTION CHALLENGES

Customer retention in India's online food delivery industry is significantly influenced by regional and economic disparities between Tier-I and Tier-II cities. In Tier-II

cities, price sensitivity is a dominant factor. Customers in these regions often prioritize affordability over premium services, making loyalty programs less effective unless explicitly value-driven. Platforms like Zomato and Swiggy face the added challenge of tailoring their marketing efforts to cater to customers with limited exposure to advanced digital tools and promotions. Additionally, cultural nuances and preferences require localized strategies that resonate with the target audience.

Another significant challenge is the logistical infrastructure in Tier-II cities. Inadequate delivery networks, traffic congestion, and resource limitations can lead to delays and errors in orders, directly impacting customer satisfaction and retention. Unlike Tier-I cities, where technological advancements and robust infrastructure support high-quality service, Tier-II cities demand more investment in delivery logistics and localized partnerships. These issues underscore the need for scalable yet region-specific solutions to overcome barriers and ensure consistent customer experiences.

CASE STUDIES

Zomato's Success in Tier-I Cities: In cities like Delhi and Bangalore, Zomato's loyalty program, Zomato Gold, has seen strong adoption. The platform has leveraged partnerships with local restaurants to offer exclusive deals to loyal customers, resulting in increased retention rates. Zomato's strategy focuses on high engagement and offering customers a broad range of dining options, contributing to its success in retaining users in Tier-I markets.

Swiggy's Expansion in Tier-II Cities: Swiggy's focus on affordability has helped it capture a significant share of the market in Tier-II cities. By offering more localized and region-specific discounts, Swiggy has been able to increase its customer base and retain users who are highly price-sensitive. Swiggy's successful retention strategy also includes improving delivery times, which is a significant challenge in smaller cities due to logistical constraints.

Zomato's Regional Advertising Campaigns in Tier-II Cities: Zomato ran targeted advertising campaigns focusing on regional preferences in cities like Pune and Surat. By adapting to the local food culture and promoting relevant offers, Zomato was able to retain customers in these cities by providing a more personalized experience. The local-specific approach led to higher engagement rates and improved customer retention.

Swiggy's Free Delivery Scheme in Smaller Cities:

Swiggy introduced a region-specific promotion offering free delivery on the first three orders in cities like Bhopal and Nashik. This initiative encouraged first-time users to engage with the platform and helped build customer loyalty by reducing the initial financial barrier for users in Tier-II cities.

Zomato's Impact of Regional Cuisine Choices in Tier-II Cities: Zomato's ability to offer local and regional cuisine options in smaller cities has played a significant role in customer retention. For instance, in cities like Lucknow and Kochi, Zomato has tailored its offerings to feature local food preferences, contributing to higher user retention and brand loyalty.

Challenges in Tier-II cities include logistical hurdles, price sensitivity, and lower frequency of orders. While customer retention in Tier-I cities is relatively stable due to higher engagement and disposable income, Tier-II cities pose unique challenges. The opportunity lies in customizing retention strategies to cater to local preferences, enhancing service delivery, and creating value-driven loyalty programs.

Opportunities include expanding local restaurant partnerships, offering region-specific promotions, and investing in delivery infrastructure to reduce delays. Additionally, focusing on increasing brand awareness and customer education regarding the benefits of subscription services may prove beneficial for platforms like Zomato and Swiggy in Tier-II cities.

ANALYSIS AND FINDINGS

Trends in Customer Retention Strategies of Zomato and Swiggy Zomato and Swiggy both implement a range of customer retention strategies, with varying success across different regions. Key strategies include:

Loyalty Programs: Both Zomato and Swiggy have popularized their subscription-based loyalty programs, with Zomato Gold and Swiggy Super offering benefits like free deliveries and exclusive discounts. These programs are heavily promoted in Tier-I cities but have a more gradual uptake in Tier-II cities, where cost-conscious customers are less likely to spend on subscriptions without perceiving clear value.

Personalized Marketing: Both platforms use data analytics to tailor marketing efforts based on customer preferences. In Tier-I cities, where customers have higher digital engagement, personalized notifications, discounts, and

advertisements based on past orders and searches are highly effective. In Tier-II cities, however, the response rate to these personalized offers is lower, possibly due to less frequent app usage and limited exposure to advanced marketing tactics.

Pricing Strategies: Tier-I cities exhibit more elasticity in spending on food delivery services, with customers more willing to pay for convenience and premium services. In contrast, Tier-II cities tend to have a more price-sensitive customer base, with platforms like Zomato and Swiggy providing more frequent discounts and offers to attract and retain customers.

Quality of Service: Consistent delivery quality is a critical retention factor in both Tier-I and Tier-II cities. Zomato and Swiggy have been enhancing their delivery infrastructure, including tie-ups with local delivery personnel, to ensure timely and accurate deliveries. However, in Tier-II cities, logistical challenges, such as traffic congestion and poor infrastructure, can lead to delays, affecting customer satisfaction.

Customer Preferences, Spending Habits, and Engagement Metrics in Tier-I vs. Tier-II Cities In Tier-I cities, the demand for online food delivery is driven by convenience, variety, and speed. Customers in cities like Mumbai, Bangalore, and Delhi frequently use food delivery services due to busy lifestyles, a greater range of food options, and higher disposable incomes. Customer preferences lean towards a wide variety of cuisine options, as well as fast and reliable delivery services. Spending habits in Tier-I cities are less price-sensitive, with users willing to pay a premium for quicker and higher-quality service.

Conversely, in Tier-II cities, such as Nagpur, Jaipur, and Indore, food delivery is often seen as a luxury. Customers in these cities are more budget-conscious, favoring affordable pricing over premium services. The menu variety is also limited, and food delivery services are typically less frequent. Although the frequency of orders is lower, when customers do place orders, they tend to spend less, looking for value-for-money options. Engagement metrics, such as app usage and order frequency, are also lower in Tier-II cities compared to their Tier-I counterparts.

FUTURE SCOPE OF RESEARCH

Future research can explore the impact of emerging technologies like AI and machine learning in enhancing customer retention strategies for online food delivery platforms. These technologies could enable advanced

predictive analytics, allowing platforms to anticipate customer needs and personalize their offerings more effectively. Additionally, studying the role of hyperlocal marketing in Tier-II cities could provide insights into how regional preferences and cultural nuances influence customer retention.

Another promising area is the examination of partnerships between food delivery platforms and local restaurants. Research could focus on how these collaborations contribute to improved menu variety, affordability, and customer satisfaction. Expanding the scope to include Tier-III cities and rural areas could also offer valuable perspectives on untapped markets and their unique customer retention challenges.

CONCLUSION

Customer retention is pivotal for the success of online food delivery platforms like Zomato and Swiggy, especially in the competitive and diverse Indian market. This research highlights the critical differences in customer behavior, spending patterns, and engagement metrics between Tier-I and Tier-II cities. Strategies like loyalty programs, personalized marketing, and competitive pricing have proven effective in Tier-I cities due to higher disposable incomes and digital literacy. However, Tier-II cities present unique challenges such as price sensitivity, logistical constraints, and regional preferences that require tailored approaches.

To address these challenges, platforms must focus on region-specific adaptations, including more affordable and localized loyalty programs, personalized marketing aligned with cultural nuances, and investments in improving delivery infrastructure. By leveraging insights from Tier-I cities while addressing the distinct dynamics of Tier-II markets, Zomato and Swiggy can enhance customer retention, ensure long-term growth, and strengthen their market presence across different city tiers. This research provides actionable recommendations for adapting

strategies to the evolving needs of Tier-II customers, contributing to the overall resilience and profitability of the online food delivery industry.

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Overview of Business Analytical Techniques

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ABSTRACT

Analytics practices play a key role in various businesses such as healthcare, finance, and engineering by transforming raw data into actionable insights for decision-making. These practices include a wide range of methods, from basic descriptive analytics to complex machine learning models used for predictive and prescriptive analytics. This paper provides a comprehensive overview of key analytical techniques, categorized by their objectives and methodologies. It explores various techniques such as descriptive, diagnostic, predictive, prescriptive, and causal analytics, along with methods used in analytics. The paper also highlights tools commonly used to implement these techniques, offering a detailed perspective on their applications and significance in real-world scenarios.

KEYWORDS : *Descriptive, Diagnostic, Predictive, Prescriptive, Causal analytics.*

INTRODUCTION

In the data-driven world of the 21st century, analytics has become a crucial tool for any business or organizations seeking to extract meaningful insights from vast amounts of data. The ability to analyse, understand, and act upon data helps businesses to improve operations, forecast trends, and innovate products and services and get added competitive advantage over competitor.[2] Analytical techniques are designed to achieve specific objectives, ranging from understanding past performance to anticipating future events and recommending the best course of action.[1][2]

This paper includes a descriptive study of various analytical techniques, discussing their key methodologies, tools, and applications across varied fields.[1] The techniques explored in this paper are categorized based on their primary objectives: descriptive, diagnostic, predictive, prescriptive, and causal analytics.[2]

LITERATURE REVIEW

The concept of business analytics dates back to the 1950s, when early forms of data investigation were used to enhance business operations. However, business analytics in its modern form began to gain fame in the late 1990s with the rise of enterprise resource planning (ERP) systems, customer relationship management (CRM) systems, and data warehousing solutions (Davenport, 2006).

Business Intelligence (BI) has traditionally been the predecessor to modern BA, primarily focused on reporting and querying data. In the 2000s, the integration of BI with more advanced analytics led to the development of business analytics. The ability to use BI tools for deeper, more predictive insights transformed BA from a descriptive reporting tool into a dynamic decision-making asset (Chen et al., 2012).

In the last decade, the rise of big data, machine learning, and artificial intelligence has greatly expanded the scope

of business analytics. Predictive and Prescriptive analytics, previously limited to specialized industries like finance and marketing, have become widespread in diverse sectors such as supply chain management, healthcare, and human resources (McKinsey, 2018).

Descriptive analytics refers to the use of past data to comprehend and describe past performance. Studies suggest that descriptive analytics tools, such as dashboards and reports, are commonly used for operational reporting and performance monitoring (Shmueli & Koppius, 2011). Descriptive analytics offers foundational insights that are serious for understanding business operations.

Diagnostic analytics deals on classifying the reasons behind past events. It is often used in business to expose origin causes of problems or failures. Regression analysis, correlation analysis, and decision trees are often employed in this context (Chen et al., 2012). For example, diagnostic analytics in marketing can help businesses know why customer churn has increased by evaluating the factors that affect customer behaviour.

Predictive analytics past historical data and machine learning algorithms to predict forthcoming movements and behaviours. Several studies have confirmed the utility of predictive models in predicting sales, customer demand, and financial performance. For example, Waller & Fawcett (2013) showed how predictive analytics helped businesses in supply chain management by prediction demand and enhancing inventory levels.

Prescriptive analytics offers actionable references to enhance outcomes. Techniques such as optimization algorithms, decision analysis, and simulation are often employed to suggest the best possible actions. Prescriptive analytics is often used in industries like healthcare and finance, where optimal decision-making can lead to significant cost savings and improved outcomes (Delen et al., 2013). For example, prescriptive analytics in healthcare helps hospitals regulate the most competent recruitment levels and patient handling strategies.

METHODOLOGY

Descriptive Analytics

Definition and Purpose: - Descriptive analytics is the process of analysing historical data to gain insights into past performance.[3] This technique helps to review and explain what has happened in a given period, often using aggregated data and various visualizations to expose patterns or trends.[4]

Key Technique

- **Summary Statistics:** Measures such as Measures of central tendency like mean, median, standard deviation, and range help to summarize data.[4]
- **Data Visualization:** Graphs and charts such as bar graphs, line charts, and histograms make it informal to interpret data visually.[3]
- **Trend Analysis:** Identifying patterns or trends over time, such as sales development or falling customer holding.

Tools

- **Excel:** A typically used tool for basic descriptive statistics and visualization.[4]
- **Tableau:** A sturdy data visualization tool that facilitates the formation of collaborating dashboards.[4]
- **Power BI:** A Microsoft tool that offers different database connection and visualizations and business intelligence capabilities.

Applications

- **Business Report:** Dashboards and performance reports are often built using descriptive analytics to provide insights into the organization's key performance indicators (KPIs).
- **Customer Insights:** Descriptive analytics is used to understand customer demographics, purchasing behaviors, and preferences.[4]

Diagnostic Analytics Definition and Purpose

Diagnostic analytics seeks to know the reasons behind past actions. It goes beyond descriptive analytics by finding relationships and correlations between variables. This practice helps uncover why something happened, providing a deeper understanding of the data.[6]

Key Technique

- **Correlation Analysis:** Observes the association between two or more variables to determine the strength of their association.[6][7]
- **Regression Analysis:** Used to model the relationship between two or more than two variable such as one is dependent variable and one or more independent variables.[3][5]
- **Root Cause Analysis:** A process of classifying the fundamental cause of a problem or issue.[6]

Tools

- SPSS: It's a software for Statistical Package for the Social Sciences, Used for statistical analysis, regression demonstration, and hypothesis testing.[3]
- Python: Python libraries like pandas and statsmodels are used for regression analysis and correlation [6][7]
- R: A programming language used for statistical programming and data analysis.

Applications

- Marketing Analytics: Identifying why certain promotion strategies perform better than others.[2]
- Operations and Quality Control: Analyzing production defects or working incompetence to locate root causes.[3]

Predictive Analytics

Definition and Purpose: - Predictive analytics uses historical data to predict future outcomes. It applies statistical algorithms, machine learning models, and time series analysis to make informed forecasts about future trends, behaviours, or events.[7]

Key Technique

- Machine Learning Algorithms: Methods such as decision trees, random forests are used for classification and regression tasks.[5]
- Time Series Analysis: Methods like ARIMA (Autoregressive Integrated Moving Average) are used for forecast based on past values, trends and cycles
- Neural Networks: Deep learning algorithms, such as AI neural networks, are used for complex pattern recognition and prediction.[6]

Tools

R and Python: Both programming languages are extremely used for machine learning and time series forecasting.

SAS: Software that offers predictive modelling solutions [3]

Applications

- Demand Forecasting: Expecting future customer demand helps in inventory management and supply chain optimization.
- Customer Segmentation: Predictive models identify groups of customers who are most likely to purchase

specific products, enabling targeted marketing efforts. [5]

- Risk Management: Predicting risks such as financial defaults, cybersecurity threats, or operational disturbances allows companies to take preventive actions.

Prescriptive Analytics

Definition and Purpose: - Prescriptive analytics aims to reference actions that should be taken to enhance outcomes. It goes a step further than predictive analytics by suggesting the best imaginable course of action based on the data analysis.[6]

Key Technique

- Optimization Algorithms: Linear programming, genetic algorithms, and other optimization approaches suggest the best solution.[4]
- Simulation Models: Monte Carlo simulations and discrete event simulations help predict different situations and evaluate risk.[4][5]
- Decision Trees: A tool used for modelling decisions and likely consequences to aid in decision-making.[6]

Tools

- IBM ILOG CPLEX: Used for optimization problems.
- AnyLogic: A simulation tool for model-based decision-making.[8]
- Gurobi: A viable optimization problem solver for linear programming and mixed-integer programming. [6]

Applications

- Supply Chain Optimization: Prescriptive analytics is used to improve inventory levels, delivery schedules, and procurement decisions.
- Financial Portfolio Optimization: It helps in determining the best asset allocation to maximize returns and minimize risk.[10]
- Pricing Optimization: Using prescriptive models to recommend the best pricing approaches based on market situations, competition, and customer behavior.[10]

CONCLUSIONS

Business analytics practices have grown from basic reporting tools to cultured methods that help organizations make informed decisions, optimize operations, and predict future outcomes. Descriptive, diagnostic, predictive, and prescriptive analytics each serve a unique role in the analytics ecosystem, and organizations are increasingly including these techniques to enhance business performance. With the advent of, real-time analytics, machine learning and big data technologies, the upcoming of business analytics promises even better advancements, enabling businesses to stay in advance of the curve in an ever-competitive marketplace.

The continued development and integration of these techniques will empower businesses to solve new levels of competence, profitability, and customer satisfaction. As organizations face an ever-expanding volume of data, the capability to evaluate, understand, and act on that data quickly will be essential for long-term success in business.

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A Comprehensive Analysis of Financial and Operational Metrics: Profitability, Efficiency, Market Valuation, and Performance Across Sectors

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ABSTRACT

This report provides an in-depth analysis of key financial and operational metrics aimed at evaluating the profitability, efficiency, market valuation, and overall performance of companies across multiple sectors. The study focuses on critical indicators such as Net Profit (NP), Return on Capital Employed (ROCE), Return on Equity (ROE), Price-to-Earnings (P/E) ratio, Dividend Yield, Gross Profit Margin (GPM), and Inventory Turnover. Companies like ITC, Hindustan Unilever, and Nestlé India demonstrate superior profitability and efficiency, setting benchmarks in their respective industries. Smaller players such as Krishival Foods and Dodla Dairy face challenges in profitability and valuation. By exploring these metrics, this report provides investors with valuable insights to make informed decisions based on financial health, market positioning, and long-term growth potential.

KEYWORDS : *Return on capital employed (ROCE), Return on equity (ROE), Net profit, Price-to-earnings ratio (P/E), Gross profit margin (GPM), Net profit margin (NPM), Inventory turnover, Free cash flow (FCF).*

INTRODUCTION

The landscape of India's consumer goods sector tells a compelling story of transformation, ambition, and strategic excellence. At its heart, this is a tale of established giants and emerging challengers, each carving their own path in one of the world's most dynamic markets. [1].

Leading the pack are the traditional powerhouses

- Hindustan Unilever, ITC, and Nestle India. These companies have built their success on decades of consumer trust, operational excellence, and deep market understanding. HUL, with its vast portfolio of household brands, exemplifies how premium positioning and operational efficiency can create sustained market leadership. Nestle India's remarkable performance in capital efficiency and profit margins demonstrates the power of focused strategy and brand strength. ITC stands out as a unique player, successfully balancing profitability

with reasonable market valuations while offering attractive returns to shareholders. [2]

The middle tier of the market presents its own fascinating narrative. Companies like Marico and Varun Beverages have carved strong niches through focused strategies and efficient execution. Marico's success in maintaining healthy profitability despite intense competition speaks to the power of brand building and market understanding. Varun Beverages represents a growth story, though its journey includes challenges in managing rapid expansion and cash flow demands. [3]

Perhaps the most intriguing stories come from the emerging challengers. Companies like Avanti Feeds, Dodla Dairy, and Gopal Snacks operate in specialized segments, bringing innovation and efficiency to their chosen markets. Dodla Dairy's excellence in inventory management stands as a testament to operational efficiency, while

Avanti Feeds represents the potential of focused niche strategies. These companies, though smaller in scale, often demonstrate agility and market responsiveness that their larger competitors might envy. [4]

Working capital management emerges as a key theme in this sector's story. The contrast between companies is stark - while some demonstrate exceptional efficiency in managing their operations, others struggle with basic inventory turnover and cash flow management. This operational efficiency often marks the difference between thriving and merely surviving in this competitive landscape.[5]

The valuation narrative in this sector is equally compelling. Market leaders command premium valuations, reflecting their strong brands and consistent performance. However, these high valuations also create their own challenges, leaving little room for execution missteps. In contrast, smaller players often trade at more modest valuations, creating potential opportunities for value investors willing to look beyond the obvious market leaders. [6].

The sector's evolution mirrors the broader transformation of Indian consumer preferences. Premium segments continue to grow as Indian consumers upgrade their lifestyle choices, benefiting companies with strong brand equity. Simultaneously, the value segment, particularly in rural markets, offers

As India's consumption story continues to unfold, the consumer goods sector stands as a testament to the country's economic vitality and potential. It remains a sector where tradition meets innovation, where scale meets efficiency, and where brand power meets operational

excellence. Understanding these dynamics is crucial for anyone seeking to participate in or learn from one of India's most vibrant business sectors. [10]

growth opportunities for companies that can build efficient cost structures and strong distribution networks. [7]

Looking ahead, the sector's future appears to be shaped by several key trends. The increasing sophistication of Indian consumers creates opportunities for premium products and services. Digital transformation is reshaping distribution channels and consumer engagement. Sustainability and health consciousness are emerging as key factors in consumer choices. These trends create both opportunities and challenges for all players in the market. [8]

For investors, the sector offers multiple themes-from stable growth in market leaders to value opportunities in smaller players. The key to successful investment lies in understanding the interplay between brand strength, operational efficiency, and market positioning. A balanced approach might combine positions in market leaders offering stability with selective investments in emerging players that offer growth potential. [9]

The story of India's consumer goods sector is ultimately one of adaptation and resilience. It's a narrative where established leaders maintain their dominance through continuous innovation and operational excellence, while emerging players carve out their own success through focus and efficiency. This dynamic creates a rich tapestry of opportunities for those who can appreciate both the stability of established businesses and the potential of emerging challengers.

ANALYSIS: SOURCE [11]

Find below the tabulation of 12 selected stocks from consumer staples showing various ratios suitable for analysis of stocks in the consumer staples sector.

S N	Script	CMP Rs.	Div Yld %	NP Qtr Rs. Cr.	ROCE %	EPS 12MRs.	ROE%	Inve n TO	GPM Qtr%	CMP/ FCF	NPM Qtr %	P/E
1	HUL	2540.0	1.6	2989.0	27.2	45.7	20.2	6.6	51.3	57.8	16.5	57.7
2	ITC	462.9	2.9	5054.4	37.5	16.5	28.4	2.2	55.9	39.8	24.4	28.3
3	Nestle	2354.4	0.7	696.1	169.1	34.9	135.3	4.9	56.4	113.5	14.6	72.4
4	Britannia	5297.6	1.3	531.6	48.9	88.5	57.1	8.3	41.5	81.1	11.4	59.3
5	Marico	695.8	1.3	406.0	43.1	12.4	38.5	3.3	49.5	79.4	14.5	56.1
6	Varun Bev	573.3	0.2	628.8	28.8	7.8	35.2	3.8	55.5	-1675.7	13.1	76.4
7	Godfrey Phillips	5128.8	1.1	248.3	22.2	173.8	19.0	2.1	42.2	60.0	17.9	28.2
8	Avanti Feeds	722.0	0.9	121.5	20.0	30.7	15.1	5.2	22.8	188.1	9.0	23.5

9	Dodla Dairy	1134.7	0.3	63.6	22.1	39.8	15.5	9.2	28.2	394.2	7.1	28.7
10	Gopal Snacks	349.9	0.3	28.9	32.0	7.8	29.2	6.0	29.0	109.2	7.2	44.8
11	Chamanlal Setia	344.1	0.6	26.7	20.3	21.5	17.4	2.2	22.1	-43.3	7.2	16.0
12	Krishival Foods	250.0	0.1	8.3	13.0	5.8	10.3	1.6	30.5	-23.4	11.2	43.3

Source : Screener.in. (2024) [11]

Profitability & Efficiency Metrics: Larger, well-established companies like ITC and HUL demonstrate stronger earnings capacity, while smaller companies are still in the growth phase.

Net Profit (NP Qtr Rs. Cr.): Net profit is an essential indicator that reflects the company's ability to generate earnings after expenses. Among the companies analyzed; ITC shows the highest quarterly net profit of ₹5054.43 Cr, indicating robust earnings from its diverse portfolio in FMCG, cigarettes, and hotels. Hindustan Unilever (HUL) follows with a net profit of ₹2989 Cr, benefiting from its premium consumer product offerings. On the contrary, smaller firms like Krishival Foods (₹8.29 Cr) and Dodla Dairy (₹63.57 Cr) report much lower profits, reflecting their more limited market presence and smaller scale of operations.

Return on Capital Employed (ROCE %): ROCE is a key metric used to measure the efficiency of a company in generating profits from its capital investments. Companies like Nestlé India, Britannia, and Marico demonstrate strong capital efficiency, while smaller players, such as

Krishival Foods, face challenges in leveraging their capital effectively. Nestlé India stands out with an extraordinary ROCE of 169.08%, signifying exceptional capital efficiency. Britannia Inds. (48.92%) and Marico (43.08%) also exhibit strong capital efficiency. Conversely, Krishival Foods (12.99%) has the lowest ROCE, suggesting less efficient use of capital and operational challenges.

Return on Equity (ROE %): ROE evaluates how effectively a company generates profit relative to its equity capital. Higher ROE indicates better shareholder value generation, with Nestlé India setting a remarkable standard. Nestlé India leads with a stellar ROE of 135.33%, signaling outstanding returns for shareholders. ITC (28.43%) and HUL (20.24%) also present solid ROE figures, offering a strong return on shareholder investment. Krishival Foods (10.3%) shows the weakest ROE, pointing to less effective profitability for shareholders. [12]

Valuation & Market Perception : Price-to- Earnings Ratio (P/E) – Market Valuation: The P/E ratio provides

insight into how much investors are willing to pay for each unit of earnings. Companies with low P/E ratios may present value opportunities, while those with high P/E ratios are typically priced for strong future growth. Chamanlal Setia (15.96) and Avanti Feeds (23.53) exhibit low P/E ratios, suggesting that these companies might be undervalued or less favored by investors. Varun Beverages (76.35) and Nestlé India (72.39) have high P/E ratios, indicating that investors have high growth expectations for these companies, though they may be overpriced.

CMP/FCF (Current Market Price to Free Cash Flow) – Cash Flow Valuation: A negative CMP/FCF ratio is a red flag, as it indicates poor cash flow generation. Investors should exercise caution with companies exhibiting negative or very high CMP/FCF ratios, as they may signal cash flow inefficiencies or overvaluation. Varun Beverages (-1675.7) and Chamanlal Setia (- 43.33) show negative CMP/FCF values, which suggest inefficiencies in generating free cash flow. On the other hand, Dodla Dairy (394.2) has a high CMP/FCF ratio, which implies that its stock is expensive relative to its free cash flow. [13]

Dividend Yield – Income Generation for Investors: Dividend yield is an attractive metric for income-focused investors. It shows the percentage return based on dividends. ITC stands out for income- focused investors seeking consistent dividend returns. ITC offers the highest dividend yield of 2.94%, making it an appealing choice for income investors. HUL (1.63%) and Britannia (1.33%) provide stable, reliable dividends. Krishival Foods (0.08%) offers minimal dividends, indicating a focus on reinvesting earnings back into the business. [14]

Margins & Operational Efficiency: Gross Profit Margin (GPM %) – Pricing Power & Cost Control: GPM is a key indicator of a company's pricing power and cost management. Strong GPM, as seen in Nestlé India and ITC, reflects superior pricing power and operational efficiency. Nestlé India (56.39%) and ITC (55.9%) lead the sector in GPM, showing their ability to maintain high margins despite fluctuating costs. Chamanlal Setia (22.07%) and Avanti Feeds (22.84%) report lower margins, indicating

that these companies operate in highly competitive industries with tight margins.

Net Profit Margin (NPM %) Bottom-Line Efficiency:

NPM measures the percentage of revenue that translates into profit. A high NPM indicates strong profitability, with Nestlé India and HUL demonstrating excellent cost control and efficient operations. HUL (16.49%) and Nestlé India (14.56%) report the highest NPM, reflecting superior bottom-line efficiency. Chamanlal Setia (7.23%) and Dodla Dairy (7.05%) have lower margins, signifying potential challenges in converting revenue into profit. [15]

Inventory Turnover – Operational Efficiency: Inventory turnover measures how efficiently a company sells and replaces its stock. High turnover is typical of fast-moving consumer goods, while lower turnover reflects slower-moving items with longer shelf lives. Dodla Dairy (9.21) and Britannia (8.27) report high turnover, reflecting fast-moving products that quickly translate into sales. ITC (2.19) and Godfrey Phillips (2.1) have low turnover, which is typical for products with longer shelf lives, such as cigarettes and FMCG goods. [16]

MAJOR FINDINGS

Best Overall Performers

- Nestlé India stands out due to its exceptional efficiency, profitability, and high shareholder returns. Although its valuation is high, the company's strong fundamentals justify its premium.
- ITC presents an attractive option for passive income investors with its solid dividend yield, reasonable valuation, and robust profit generation.
- Hindustan Unilever offers a balanced mix of growth, profitability, and operational efficiency, making it an excellent investment for steady returns. [17]

Value Picks (Lower Valuation, Strong Potential)

- Chamanlal Setia stands as an undervalued pick with a low P/E ratio, though concerns over cash flow should be considered.
- Avanti Feeds is a promising choice, showing a good balance between valuation and growth prospects. [18]

High Growth, Expensive Stocks

- Varun Beverages is a high-growth company with an expensive valuation, making it a speculative choice.

- Britannia presents a strong brand and growth potential but at a high price, potentially limiting value for price-conscious investors. [19] [20]

Risky or Weak Performers

- Krishi Val Foods faces profitability challenges, reflected in low ROCE and ROE, making it a risky investment.[21]
- Dodla Dairy is costly in terms of valuation (CMP/FCF), which may not justify its current performance. [22]

CONCLUSION

The Indian consumer goods sector presents a fascinating landscape of contrasts, where established giants compete with ambitious challengers in a market characterized by evolving consumer preferences and varying operational efficiencies. Through a detailed analysis of twelve prominent companies in this sector, clear patterns emerge regarding market positioning, operational excellence, and value creation strategies. [23]

At the apex of this market stand the traditional powerhouses - Hindustan Unilever (HUL), ITC, and Nestle India. These companies have established themselves not merely as market leaders but as benchmarks of operational excellence. HUL, with its impressive gross profit margin of 51.31% and robust return on capital employed (ROCE) of 27.24%, exemplifies the benefits of premium positioning and operational efficiency. Similarly, Nestle India's extraordinary ROCE of 169.08% and industry-leading gross profit margin of 56.39% demonstrate the power of strong brand value and efficient capital utilization.

However, it is ITC that presents perhaps the most compelling investment case among the market leaders. With the highest net profit margin of 24.38% in the quarter, an attractive dividend yield of 2.94%, and a relatively modest P/E ratio of 28.25x, ITC combines profitability with reasonable valuation - a rare combination in this sector. This balanced profile suggests that even among premium- valued market leaders, pockets of value can exist.[24]

The middle tier of the market reveals interesting dynamics, particularly in companies like Marico and Varun Beverages. Marico maintains healthy profitability with a gross profit margin of 49.5% and a strong ROCE of 43.08%, indicating efficient operations despite intense competition. Varun Beverages, while showing promising growth metrics,

presents a more complex picture with its negative CMP/FCF ratio of -1675.7x, suggesting challenges in cash flow management despite strong growth prospects.

Perhaps the most intriguing opportunities lie in the emerging challengers segment. Companies like Avanti Feeds, Dodla Dairy, and Gopal Snacks operate with lower margins but demonstrate potential for significant growth. Dodla Dairy, for instance, leads the entire sector in inventory turnover at 9.21x, suggesting superior operational efficiency in working capital management.

Similarly, Avanti Feeds, with its modest P/E ratio of 23.53x and healthy operating metrics, represents a potential value opportunity in a generally expensive sector.

The sector's valuation landscape tells its own story. The premium valuations commanded by market leaders - evidenced by P/E ratios ranging from 57.67x for HUL to 72.39x for Nestle India - reflect strong brand moats and consistent performance. However, these high valuations also suggest limited room for error and potential vulnerability to any growth disappointments. In contrast, smaller players like Chamanlal Setia, trading at a P/E of 15.96x, offer value propositions albeit with higher execution risks. [25]

Working capital management emerges as a key differentiator across the sector. The stark contrast between Dodla Dairy's superior inventory turnover and Krishival Foods' modest 1.58x turnover ratio highlights the operational challenges faced by smaller players. This difference in operational efficiency often translates into varying levels of profitability and market perception. [26]

From an investment perspective, the sector demands a nuanced approach. While market leaders offer stability and strong execution capabilities, their high valuations suggest the need for selective entry points. Mid-tier companies present opportunities for growth at relatively reasonable valuations, though careful analysis of operational metrics is crucial. The emerging challengers segment, while offering the highest potential returns, requires careful evaluation of execution capabilities and financial strength. [27]

Looking ahead, the sector's evolution will likely be shaped by several key trends. The increasing premiumization of Indian consumer preferences benefits companies with strong brand equity and premium positioning. However, the simultaneous growth of the value segment, particularly in rural markets, creates opportunities for companies with efficient cost structures and strong distribution networks. [28]

In conclusion, the Indian consumer goods sector reflects the broader evolution of the Indian economy - a market where established leaders maintain their dominance through operational excellence and brand strength, while emerging players carve out niches through innovation and efficiency. For investors, the sector offers multiple investment themes.

- from stable growth in market leaders to value opportunities in smaller players. The key to successful investment in this sector lies in balancing the premium commanded by quality with the growth potential offered by emerging challengers, while maintaining a sharp focus on operational efficiency and working capital management. [30]

The optimal strategy might well be a barbell approach - combining positions in market leaders like ITC (offering stability and reasonable valuations) with selective investments in emerging players like Avanti Feeds or Dodla Dairy (offering value and growth potential). This approach would provide exposure to both the sector's stability and its growth dynamics, [31] while maintaining a focus on fundamental quality and valuation discipline. [32]

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