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Message from Chief Editor

It is my privilege to present the inaugural volume of PICT's International Journal of Engineering and Technology. As Chief Editor, I am thrilled to introduce the culmination of rigorous research and scholarly contributions in this first issue. This journal aims to serve as a beacon of knowledge, fostering innovation and advancement in engineering and technology fields.

Within these pages, readers will discover a wealth of insights and discoveries that showcase the forefront of technological evolution. Volume 1 - Issue 1 of our journal reflects the dedication and scholarly pursuit of our contributors. Their work not only expands upon the current state-of-art technologies but also provides invaluable insights into their practical applications.

PICT's IJET is committed to fostering discourse and collaboration in the global academic community. Through the dissemination of cutting-edge research, we strive to catalyze progress and drive positive change in the world. As we embark on this mission together, I invite readers to immerse themselves in the rich web of knowledge presented within these pages.

I extend my heartfelt gratitude to all the authors, reviewers, and editorial team members whose tireless efforts have made this publication possible. May Volume 1 - Issue 1 of PIJET inspire curiosity, innovation, and collaboration among scholars worldwide.

Dr. S. T. Gandhe
Chief Editor - PIJET
Principal
Pune Institute of Computer Technology
Pune, India.

Message from Journal Coordinator

I welcome authors, scholars, and readers alike to the Volume 1 - Issue 1 of PICT's International Journal of Engineering and Technology. Within these pages, you'll discover cutting-edge insights spanning various topics in domains like Electronics and Telecommunication, Computer Science, Information Technology, Embedded Systems, etc. Our goal is to equip you with the knowledge of emerging techniques and technologies to drive successful research in your fields.

I extend heartfelt thanks to our contributors and reviewers for their invaluable contributions. As future issues culminate, I urge readers and scholars to join us in this exploration to shape the future of engineering and technology.

Dr. R. C. Jaiswal

Journal Coordinator - PIJET
Associate Professor
Department of Electronics and Telecommunication
Pune Institute of Computer Technology, Pune, India.

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Pune, India
varsha.harpale@pccoepune.org

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Pune, India
gvkale@pict.edu

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Pune, India
mvmunot@pict.edu

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aaghotkar@pict.edu

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skmoon@pict.edu

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scdharmadhikari@pict.edu

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Dept. of E&TC Engineering PICT,
Pune, India
rgyelalwar@pict.edu

Dr. A. M. Bagade
Associate Prof.,
Dept. of IT Engineering PICT,
Pune, India
ambagade@pict.edu

Dr. K. C. Waghmare
Assistant Prof.,
Dept. of Computer Engineering PICT, Pune, India
kcwaghmare@pict.edu

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Enhancing battery life by performance analysis using ML and DL

Tanishqa Somavanshi[1], Devanshu Dhanorkar[2], Aakash Shinde[3], Pranav Bhagwan Pawar[4]

[1]Student, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India,
tanishqas23@gmail.com
[2]Student, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India,
dhanorkardevanshu@gmail.com
[3]Student, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India,
aakashbshinde2003@gmail.com
[4]Assistant Professor, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India,
pbpawar@pict.edu

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Abstract:

Lithium-ion battery packs find extensive use in numerous high-power applications, including electric vehicles (EVs) and smart grids, necessitating the implementation of a battery management system (BMS). The efficient management of lithium-ion batteries is crucial for optimizing the performance and lifespan of various applications, including electric vehicles and renewable energy systems. This research focuses on advancing battery state estimation techniques using DNN and LSTM models. The work aims to develop accurate models for estimating the lithium-ion batteries' state of health (SOH) and remaining usable life (RUL). The outcomes demonstrate the excellent forecast accuracy of the suggested strategy.

***Keywords*— Machine learning, Deep learning, battery management systems, state of health, remaining useful life.**

1. INTRODUCTION & LITERATURE SURVEY

In recent decades, the increasing usage of traditional power production sources and automobiles which emit carbon dioxide is one of the causes of the Earth's climatic deterioration. This prompted the development of energy storage technologies, resulting in the development of lithium-ion (Li-ion) batteries, which have become among the best options. This is why the main power source for electric vehicles (EVs), consumer gadgets, and even spaceships is lithium-ion batteries. As a result, lithium-ion battery security and reliability are an important concern when it comes to practical applications. As batteries age, their performance naturally declines, posing risks to the reliable operation of electrical devices and potentially leading to significant consequences.

Li-ion batteries' electrical properties have advanced significantly, however, problems still arise from their non-linear charging capacity and rapid aging rates. The installation of an effective battery management system is essential to resolving these problems. Such a system is critical in safeguarding the battery assembly and optimizing energy utilization by monitoring key parameters such as state-of-health (SOH) and remaining useful life (RUL). By ensuring the proper functioning of the battery, including its SOH and RUL, the performance of Li-ion batteries can be optimized.

Currently, there are two primary categories of methodologies to evaluate State-of-Health (SOH) and Remaining Useful Life (RUL): model-based and data-driven methods. Model-based strategies include models with different modeling mechanisms, such as the electrochemical model and the equivalent circuit model. The electrochemical model clarifies degradation mechanisms. It is based on the physical and chemical reactions that occur within batteries.

Equivalent circuit models (ECMs) offer a less intricate alternative to more complex Electrochemical-Chemical Models (EChMs), providing a balance between simplicity and moderate accuracy suitable for real-time applications. Johnson developed two conventional ECMs: the impedance resistance-capacitance (RC) model and the battery internal resistance equivalent (Rint) model. While ECM implementation was robust, it often overlooked the implicit relationships between internal battery state variables. The simplest Thevenin model featuring a single RC branch with constant model parameters was introduced. However, utilizing ECMs for battery aging estimation necessitates numerous internal battery and resistance aging parameters, posing challenges for parameter identification due to the complexity of lithium-ion battery capacity degradation mechanisms. Furthermore, it can be difficult to identify some of the characteristics linked to side reactions that occur in tandem with the primary reaction, which results in model-based techniques performing less well in real time.

With the burgeoning advancements in machine learning and artificial intelligence, data-driven methodologies have garnered increasing attention. Furthermore, the abundance of lithium-ion battery performance data from real-world applications has facilitated the adoption of data-driven approaches for predicting battery aging. Data-driven approaches, in contrast to model-based techniques, are nonparametric and partially ignore electro-chemical ideologies. Also, various regression and mapping methods are used to construct deprivation models for li batteries.

Data-driven approaches offer a direct means to extract degradation insights and health state evolution patterns from historical data on lithium-ion batteries, bypassing the need for explicit model formulations. These techniques include neural networks and regression methods, such as autoregressive (AR) models, support vector machines (SVM), and artificial neural networks (ANN). For instance, battery Remaining Useful Life (RUL) was predicted online using an AR model enhanced by the particle swarm optimization algorithm. While the AR model boasts simplicity in computation, its predictions lack uncertainty expression. An RUL forecast technique based on the ARIMA model was proposed, albeit requiring time series data stability and stringent battery operating conditions. Another approach involved employing a dynamically driven recurrent network (DDRN) to streamline network complexity and enhance algorithm robustness, albeit with the caveat of potential gradient disappearance issues. Similarly, a regression model leveraging the SVM algorithm was established to estimate battery RUL by training on battery terminal voltage and voltage derivative during charging. However, the SVM algorithm's susceptibility to local minima poses challenges.

Various methods have been explored for predicting the remaining useful life (RUL) of batteries, including time series analysis, ANN, GPR, SVM, and relevance vector machines (RVM), among others. An enhanced autoregressive (AR) model optimized by particle swarm optimization (PSO) for online predictions. While the AR model was straightforward to compute, it lacked uncertainty quantification in the prediction results. An employed a structured neural network approach to streamline network complexity and enhance computational efficiency. However, their method provided only point estimates in prediction results and demonstrated poor performance with limited sample sizes. A multi-kernel SVM (MSVM) utilizing polynomial and radial basis kernel functions to forecast battery RUL. Nonetheless, SVM algorithms are prone to local optima due to inherent characteristics.

Some researchers have employed empirical models to characterize the capacity degradation curve and utilized estimation techniques like the PF, KF, and their enhancements such as the AUKF, UKF, IMMP filter, or models for Approximating SOH and RUL. However, empirical models fail to capture the influence of operating conditions on battery lifespan.

Semi-empirical models, grounded in aging mechanisms, offer a more comprehensive approach by considering the impact of various service conditions on battery aging performance. These models primarily incorporate external factors such as operating environment and battery usage conditions, including temperature, charge and discharge rates, depth of discharge (DOD), and charge and discharge cutoff voltage, among others.

2. PROPOSED METHODS

The open dataset made available by the NASA Ames Prognostics Center of Excellence (PCoE) is where the lithium-ion battery dataset used in this study originated. The experimental data from four lithium-ion batteries (Nos. 5, 6, 7, and 18) that underwent charging and discharging cycles and had their impedance measured at room temperature (24°C) under varied operating conditions make up the dataset. Basically two phases to the charging procedure: first, approximately 1.5 Ampere of current was given until the battery voltage reached 4.2 V; then, a constant voltage charging was done to keep the voltage at 4.2 V while lowering the current to 20 mA. Battery 5, 6, 7, and 18 voltages decreased to 2.7 V, 2.5 V, 2.2 V, and so on. Discharging was carried out at a continuous current of 2 A. The data have been taken from a Matlab (.mat) file containing an open dataset. The procedure retrieves the designated battery dataset and, focusing on discharge events in particular, pulls critical data from its cycles. It then carefully analyzes every discharge cycle, recording important data such as the surrounding temperature, the time and date, capacity, voltage, current readings, and load-related characteristics. The metrics have been methodically organized and saved in a Pandas DataFrame named 'dataset' for additional examination. Furthermore, the function aggregates information specific to battery capacity throughout several cycles into a separate data frame called 'capacity.' Once the data processing is finished, it provides a brief overview by displaying a preview of the 'dataset' DataFrame and printing the total number of data points in the dataset. This simplified method makes it easier to analyze battery data in its early stages, which allows for more effective data loading and preparation for later research endeavors.

Deep Neural Network:

DNN, or Deep Neural Network, is an artificial neural network with more than two layers. A DNN's layers are made up of several neurons, sometimes referred to as nodes or units, which use several mathematical operations to process the incoming data. DNNs are known for their depth, which refers to their several buried layers, each of which is made up of several neurons. DNNs are very useful for jobs because of their hidden layers, which enable them to learn intricate patterns and representations from the input data.

DNN consists of several key components. The following are layers contained in DNN:

Input Layer: the network's first layer, into which input data is fed. In this layer, every neuron corresponds to a feature of the incoming data. Equation (1) shows the input layer.

Hidden Layers: The network uses the intermediate layers between the input and output layers to identify patterns and representations in the input data. These layers could have one or more buried layers with many neurons in each. After receiving input from the preceding layer and assigning a weight to each input, the neurons in each buried layer transmit the outcome through an activation function. Equation (2) shows the hidden layer.

Activation Functions: To add nonlinearity to the model and help the network discover intricate links in the data, each neuron in the hidden layers usually applies a nonlinear activation function to its input. Rectified Linear Unit (ReLU), sigmoid, and tanh are some types of activation functions. They are shown by equations (5),(4) and (3) respectively.

Dropout Layer: A regularization method called dropout keeps neural networks from overfitting. During training, a portion of the neurons are randomly removed (set to zero), forcing the network to acquire more resilient characteristics. Equations (6) and (7) represented the dropout layer during training and interference respectively.

Output Layer: the network's last layer, which generates the output predictions. The type of issue determines how many neurons are in this layer. Regression tasks usually include a single neuron, however, classification tasks may involve several neurons representing various classes. The output layer is shown by equation (8).

$$X = [\, x_1, x_2, x_3, \dots, x_n \,] \quad (1)$$

$$h_l = \sigma(W_l\, h_{l-1} + b_l) \quad (2)$$

$$\sigma(x) = max(0, x) \quad (3)$$

$$\sigma(x) = \frac{1}{1+e^{-x}} \quad (4)$$

$$\sigma(x) = \frac{e^{x}-e^{-x}}{e^{x}+e^{-x}} \quad (5)$$

$$\widehat{x_i} = \begin{cases} 0\,, & with\ probaility\ p \\ \frac{x_i}{1-p}, & otherwise \end{cases} \quad (6)$$

$$\widehat{x_i} = (1-p).x_i \quad (7)$$

$$\hat{y} = W_l\, h_{l-1} + b_l \quad (8)$$

Where X represents the input features. The W and b are the weight matrix and bias vector respectively. The h and σ are the output of the hidden layer and activation function respectively.

Long Short Term Memory:

RNN architectures like LSTM networks were created to address the shortcomings of conventional RNNs in identifying long-term dependencies in sequential data. In contrast to conventional RNNs, which have trouble with vanishing or exploding gradients, long sequence memory cells (LSTM networks) allow them to retain information.

The LSTM cell consists of several key components, each playing a crucial role in the processing of sequential data:
Input Gate (*p*): The information entering the cell state is managed by the input gate. It selects the data that should be kept in the current cell state from the input and the previous cell state. The input gate determines how much each component of the input should be changed by taking as input its features and previously hidden states after that, it outputs a value for each cell state element ranging from 0 to 1. The input gate is represented by equation (9).
Forget Gate (*q*): The forget gate makes decisions about which data from the cell state should be discarded or forgotten. Like an input gate, it accepts input features and previously hidden states as input and outputs, for each element of the cell state, a value between 0 and 1, indicating how much of each element should be remembered or ignored. The forget gate is represented by equation (10).
Cell State (*s*): The LSTM cell's long-term memory is represented by the cell state. With the use of input gate and forget gate procedures, it updates its data storage over time. By adding fresh information (obtained from the input gate) and erasing irrelevant information (ascertained by the forget gate), the cell state is changed. Equation (11) represents the cell state.
Output Gate (*r*): This gate regulates the information transfer from the output to the cell state. It chooses which elements of the cell state should be output as the LSTM cell's final concealed state. The output gate determines how much each component of the cell state should contribute to the output by taking input features and previously hidden states as input and output a value between 0 and 1. Equation (12) shows the output gate.
Long-term dependencies in sequential data can be efficiently captured by LSTM. The network can learn and recall patterns over lengthy sequences thanks to the input gate, forget gate, and output gate, which allow it to selectively update, retain, and output information.

To enable long-term memory, the LSTM cell alternates the RNN cell in the hidden layer with an LSTM cell.

$$p_t = \sigma(\ A_{xp}x_t + A_{hp}h_{t-1} + A_{sp}s_{t-1} + d_p\ ) \quad (9)$$

$$q_t = \sigma(\ A_{xq}x_t + A_{hq}h_{t-1} + A_{sq}s_{t-1} + d_q\ ) \quad (10)$$

$$s_t = q_p s_{t-1} + p_t tanh(\ A_{xp}x_t + A_{hp}h_{t-1} + A_{sp}s_{t-1} + d_p\ ) \quad (11)$$

$$r_t = \sigma(\ A_{xr}x_t + A_{hr}h_{t-1} + A_{sr}s_{t-1} + d_r\ ) \quad (12)$$

where A and d stand for the relevant weight coefficient matrix and offset, respectively; p, q, and r represent the input gate, forgetting gate, and output gate, respectively; s represents the cell state; The hyperbolic tangent activation function (tanh) and the sigmoid function (σ) are respectively.

Optimization Algorithm and Loss Function :

Deep neural networks (DNNs) and other machine learning models are trained using optimization methods as basic building blocks. The goal of these algorithms is to minimize an objective function, often known as the loss function Adaptive moment estimation, often known as the Adam optimizer, is a well-liked optimization technique that is frequently used to train deep learning models, such as neural networks or DNNs. It effectively minimizes the loss function during training by combining the benefits of momentum approaches and adaptive learning rates by calculating the gradients' first and second moments, Adam can maintain adaptive learning rates for every parameter. It computes the first moment and second moment of exponentially decaying average estimates of historical gradients and squared gradients, respectively. Subsequently, the learning rates for every parameter are adaptively scaled using these estimations, guaranteeing quicker convergence and improved management of sparse gradients. Adam also adds momentum by adding a decay parameter to regulate the impact of previous gradients on the current update. Particularly when there are noisy gradients or excessive curvature, this momentum factor aids in accelerating convergence. All things considered, Adam provides strong performance on a variety of deep learning tasks and is renowned for its effectiveness, dependability, and user-friendliness.

$$\theta_{t+1} = \theta_t - \alpha.\frac{\widehat{m_t}}{\sqrt{\widehat{v_t}}+\epsilon} \quad (13)$$

Where $\widehat{m_t}$ and $\widehat{v_t}$ are approximations of the gradient's first and second moments respectively. α is the learning rate and θ represents weights or biases.

A loss function measures the difference between expected results and actual ground truth values in a dataset and is essential to the training process of machine learning models. It is a crucial indicator that provides information about how well the model predicts things throughout the iterative optimization process. The main goal is to reduce this difference to improve the model's forecast accuracy and model parameters. Diverse learning tasks, including regression and classification, are supported by different kinds of loss functions.
In regression settings, for example, Mean Squared Error (MSE) is widely used to penalize substantial differences between predicted and actual values. Mean Absolute Error (MAE), on the other hand, assesses the average absolute difference and gives priority to robustness. In regression tasks, the average magnitude of errors between predicted and actual values is measured using the widely used Mean Absolute Error (MAE) loss function, sometimes called L1 loss.

$$MAE = \frac{1}{n} \sum_{i=1}^{n} |\widehat{y_i} - y_i| \quad (14)$$

Where the projected value for the i'th sample is denoted by $\widehat{y_i}$, the actual (ground truth) value for the i'th sample is represented by y_i, and the total number of samples in the dataset is represented by n.

Estimation of SOH :

The model used for the estimation of SOH consists of DNN. This DNN is composed of multiple densely connected layers, each of which adds non-linearity to the model by using the rectified linear unit (ReLU) activation function. The octet of neurons that make up the input layer receives input data whose dimensionality corresponds to the quantity of characteristics present in the training dataset.

Each of the next hidden layers has eight neurons, which makes it easier to extract even more intricate representations from the input data. After the hidden layers, a Dropout layer with a 0.25 dropout rate is added to avoid overfitting. It works by randomly deactivating a portion of the neurons during training. The predictions of the model are finally generated by a single neuron output layer that lacks an activation function.

A stochastic gradient descent (SGD) variant called the Adam optimizer is used to compile the model. It is set up with specific hyperparameters (beta_1=0.9, beta_2=0.999, epsilon=1e-08) and optimized to minimize the mean absolute error (MAE) loss function, which measures the average difference between the values that are predicted and those that are observed.

Estimation of RUL :

For estimation for RUL, the LSTM model is used. To handle sequence prediction problems, the LSTM neural network architecture described in the accompanying code sample makes use of its capacity to identify long-term dependencies in sequential data. The model, which consists of several 200-unit LSTM layers, is designed to efficiently learn from the temporal dynamics found in the input sequences.

By randomly deleting a portion of the input units during training, dropout layers placed at critical spots in the architecture help to prevent overfitting, which in turn promotes generalization and strengthens the model's resilience. To enable the model to transport information across numerous time steps and learn from long-range dependencies in the input data, return sequences are enabled in each LSTM layer configuration.

The implementation of dropout layers after each LSTM layer serves to regularize the learning process of the model and prevent it from being too dependent on particular characteristics or patterns found in the training data. By using this regularization method, the model performs better on sequence prediction tasks that involve noisy or unpredictable input data and can generalize to previously unseen data.

The Adam optimizer, an efficient optimization method renowned for its effectiveness and efficiency in training deep neural networks, is then used to build the model. To reduce the loss function's mean squared error (MSE), which gauges how much the model's predictions deviate from the actual values, the optimizer modifies the model's parameters throughout training.

By ensuring that the LSTM model learns to generate precise predictions while managing the intricacies of the training data, this optimization process eventually makes it capable of doing exceptionally well in sequence prediction tasks.

3. RESULT & DISCUSSION

We conducted an in-depth analysis of various machine learning algorithms for the prediction of remaining useful life and state of charge, and finally after much analyzation came the implementation of a Deep neural network for the SOH part and a Long short-term network for the RUL part.

Figure 1 shows the capacity curve of battery 5 where the threshold capacity value is 1.4. The link between battery cycles on the x-axis and battery capacity on the y-axis is seen in Figure 1. The aging process of batteries as charging cycles go on is depicted in the accompanying graph.

The threshold value is represented by the horizontal line. "Capacity" is the label on the y-axis, and its values span from 1.3 to 1.9. "Cycle" is the name of the x-axis, which runs from 0 to 175. There seems to be a slight decrease in capacity with the number of cycles, as indicated by the markers on the graph.

The picture also shows how a battery's capacity decreases throughout recharge cycles and how much is created for several production cycles.

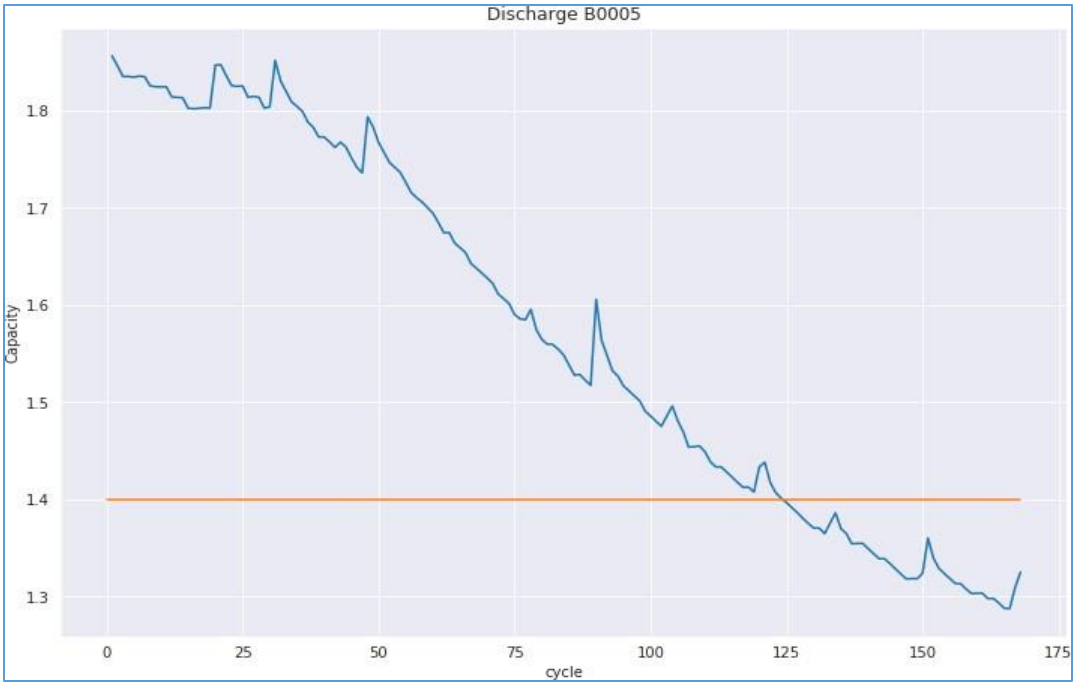

Figure 1: Battery capacity attenuation curve

Table 1 shows the calculated State of Health (SOH) that is calculated on the capacity parameter. The SOH is the ratio of the maximum releasable battery to the initial rated capacity.

$$SOH = \frac{C_{max}}{C_{rated}} \tag{15}$$

Table 1: SOH by capacity

Cycle	Capacity	SOH
0	1.856487	1.000000
1	1.846327	0.994527
2	1.835349	0.988614
3	1.835263	0.988567
4	1.834646	0.988235

Figure 2 shows the SOH curve of battery 5 where a threshold capacity value is 0.70.

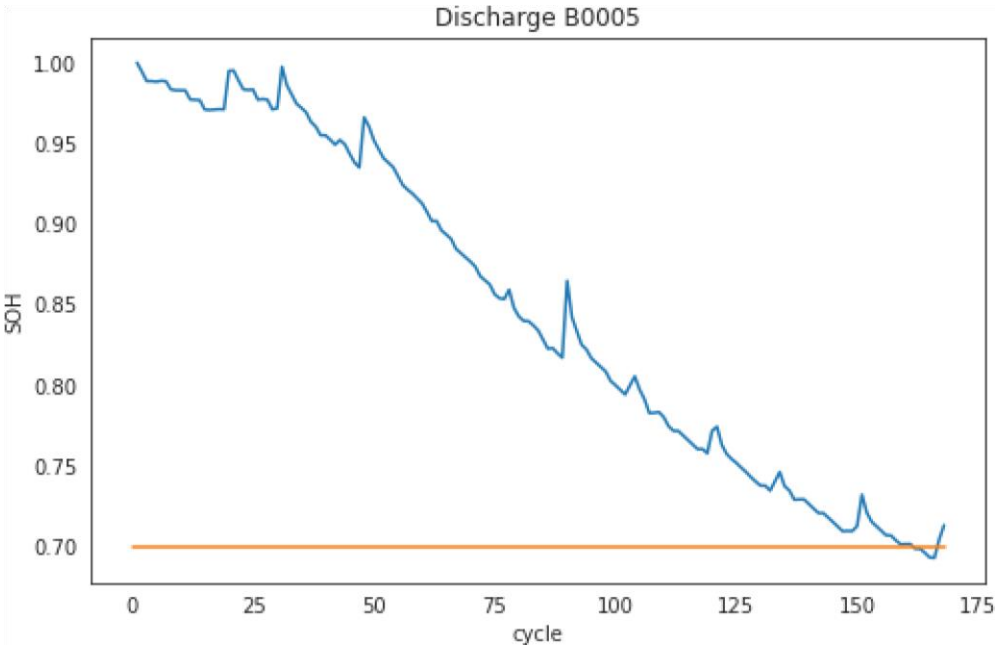

Figure 2: Battery SOH curve

The SOH on the y-axis and cycles on the x-axis are represented in the graph above. It mimics the relationship between the health of the battery and the number of cycles. After closely examining the graph, we deduce that the State of Health gradually declines as the number of cycles increases over time. For every cycle, a graph of the SOH is created like in earlier stages. The 70% mark on the horizontal line indicates that the battery has reached the limit of its useful life and needs to be replaced.

On data obtained from battery 6, using the model we predicted SOH.

Table 2 shows the comparison between SOH calculated from capacity and SOH predicted from the model. From them, the value of the root mean square error (RMSE) is 0.090887. This thus concludes that the model accuracy is precise with high correlation as the RMSE is Low.

Table 2: Comparison between SOHs

cycle	SOH by capacity	SOH by model
1	1.00000	0.959172
2	0.994990	0.956460
3	0.989185	0.953311
4	0.989165	0.953293
5	0.982898	0.949908

Figure 3 shows the visualization of SOH by capacity and by model.

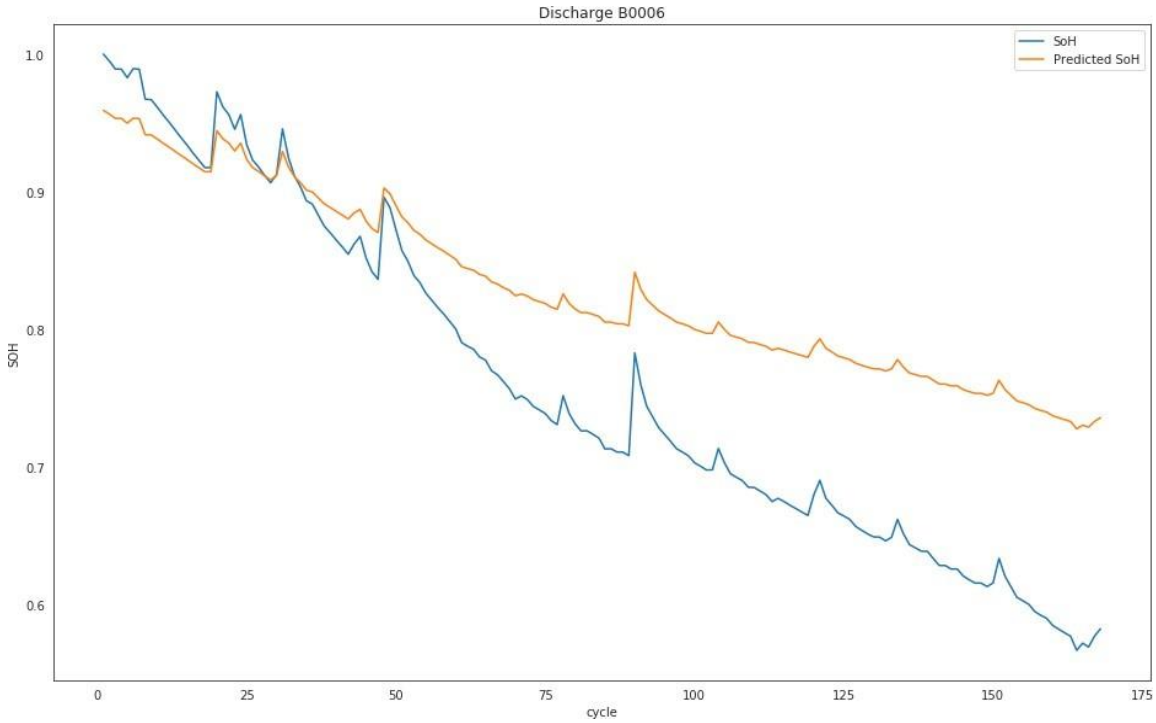

Figure 3: SOH's curve of Battery 6

Figure 3 above Lastly, a plot of the predicted and real SOH is used to illustrate the differences. This graphical representation aids in evaluating the degree to which the model's predictions agree with the actual data. Because the curve forms are almost the same, the model properly learns the data pattern for assessing the State of Health (SOH), as predicted by theory.

The State of Health (SOH) estimate and the training and testing datasets for the RUL estimate are created in the same manner. Battery capacity data is utilized in this situation. Capacity in subsequent cycles is predicted using the first data from the first 50 cycles. This enables you to calculate the battery threshold and the approximate number of cycles the battery will have left before it dies.

On data of Battery 5, The trained LSTM model runs to predict the capacity of the battery. after that comparison of predicted capacity and actual capacity, the RMSE obtained is 0.050. The obtained R^2 score is 0.8655908035539039. R-squared (R^2) score is a common metric used for evaluating linear regression models.
Figure 4 shows the plot of the battery capacity over the discharge cycles for battery 5, with a threshold of 1.4 for capacity.

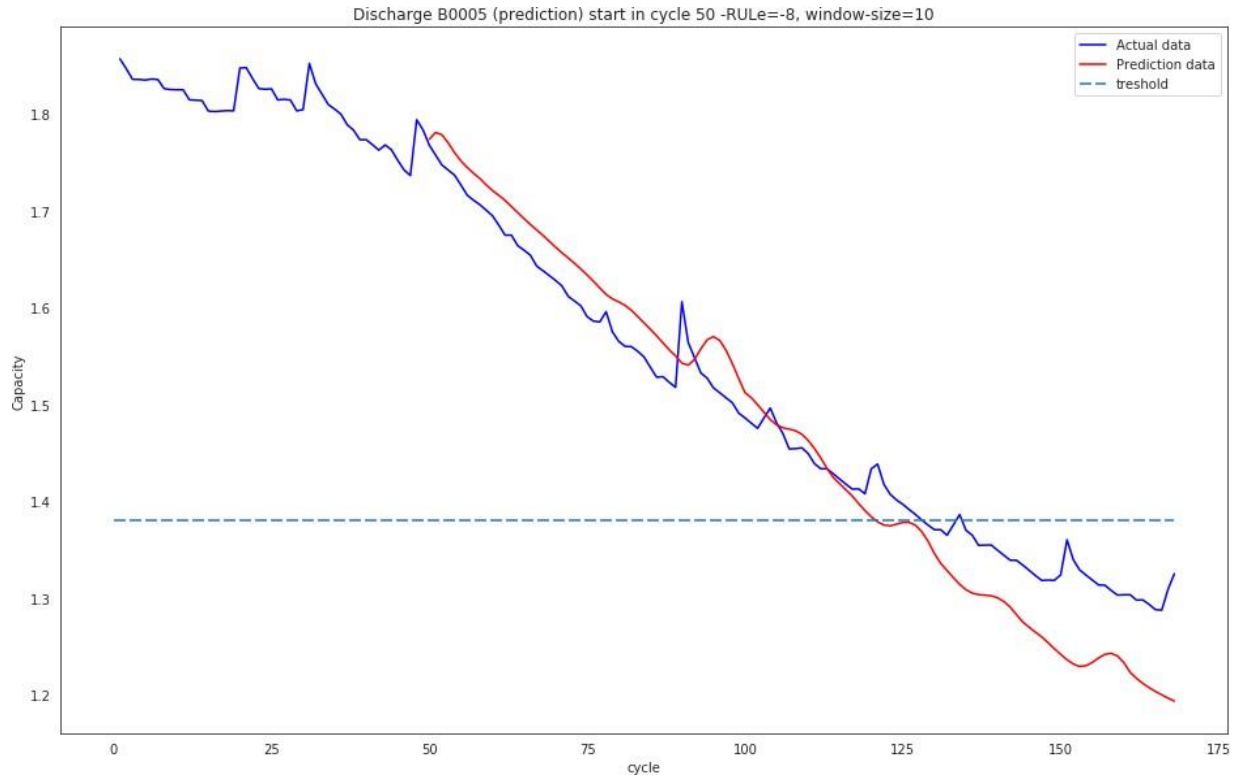

Figure 4: Capacity plot of battery 5

Finally, the graph in Figure 4. above shows that the capacity value and its trend over time roughly match the actual value. Supporting these findings, the RUL estimation error was -8, suggesting that the model anticipated the battery's life cycle end 8 cycles ahead of time.

4. CONCLUSION

In this study, we forecasted the SOH and RUL of EV batteries using deep neural networks and long short-term network techniques. With an EV battery dataset that comprised vital variables like voltage, current, temperature, and charge/discharge cycles, we aimed to build precise prediction models to anticipate battery degradation and performance over time. On the dataset, we used strict preprocessing, feature engineering, and model selection to train both DNN and LSTM models. According to our findings,

LSTM performed better than DNN in terms of RUL and SOH prediction accuracy. By putting these models into practice, EV battery management could be enhanced, lifespan could be increased, and safe and effective operation could be guaranteed. From the model for estimation for SOH and RUL, root mean square errors are 0.09087 and 0.050 respectively.

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ABBREVIATIONS

SOH	State of Health of Battery
RUL	Remaining Useful Life
DNN	Deep Neural Network
LSTM	Long Short-Term Memory
ARIMA	Auto-regressive Integrated Moving Average
ANN	Artificial Neural Network
GPR	Gaussian Process Regression
SVM	Support Vector Machine
PF	Particle Filter
KF	Kalman Filter
UKF	Unscented Kalman Filter
AUKF	Adaptive Unscented Kalman Filter
IMMPF	Interactive Multi-Model Particle Filter

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Early Detection of Abnormal Lung Condition based on Deep Learning Model

Abhishek Katke [1], Khyati Kulkarni [2], Rugved Dharmadhikari [3], Anagha Rajput [4]

[1]Student, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, abhishekkatke8602@gmail.com
[2] Student, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, guarikulkarni123@gmail.com
[3] Student, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, rugveddharmadhikari1@gmail.com
[4] Assistant Professor, SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, avrajput@pict.edu

Abstract: Lung affecting diseases are most harmful because such diseases majorly cause death of the patient. Few diseases to mention are COVID-19, pneumonia, tuberculosis, cancer and asthma. These diseases have early symptoms of lung abnormalities. Hence, detection of these abnormalities can result in effective treatment and recovering of the patient at the early stage of the disease. Image processing based on deep learning techniques are popularly used for classification and analysis of huge data like medical images. In the proposed work, a deep learning model is designed to detect abnormal lung conditions for pneumonia, tuberculosis and COVID-19. In the proposed deep learning model, convolutional neural network is implemented for analysis of medical images. The segmentation of images is based on DenseNet algorithm. Various evaluation parameters are calculated for accurate detection. This approach is implemented to address the complex challenge of classifying abnormal lung images into multiple categories and effectively distinguish between pneumonia, tuberculosis, COVID-19 and normal lung conditions. Also, the implemented model presents significant value for healthcare providers by streamlining the diagnostic process and potentially expediting treatment decisions. The evaluation process sheds light on the model's performance in real-world scenarios, providing valuable insights for further optimization and clinical integration.
Keywords: Abnormal Lung Detection, Convolutional Neural Network (CNN), Image segmentation, Deep Learning (DL), DenseNet

1. Introduction

Lung diseases represent a significant global health concern, where pneumonia, Tuberculosis (TB), and COVID-19 being major contributors to morbidity and mortality worldwide. According to the World Health Organization (WHO), most recent data from 2018, there were 10.4 million cases of lung diseases, including pulmonary TB, and 1.6 million deaths globally attributed to these conditions. Early and accurate detection of these diseases is crucial for effective treatment and recovery of the patient. Traditional diagnostic methods often rely on radiological imaging, which can be time-consuming and subjective due to inter-observer variability. In recent years, Deep Learning (DL) techniques, a subset of Artificial Intelligence (AI), have shown promising results in automating and improving the accuracy of lung disease detection from medical images.

In DL models, particularly Convolutional Neural Network (CNN) have demonstrated exceptional capabilities in feature extraction and pattern recognition from complex and high-dimensional data, making them well-suited for analyzing medical images. The integration of deep learning techniques in lung disease detection holds great promise for revolutionizing diagnostic practices, offering potential improvements in accuracy, efficiency, and accessibility [1]. However, there remain challenges to be addressed, such as data scarcity, model interpretability, and generalizability across diverse populations. Continued research and collaboration between clinicians, researchers, and AI experts are essential to overcome challenges and to understand the potential of DL in advancing lung disease diagnosis and treatment. This work aims to explore and discuss the implementation of DL technique for lung disease detection, highlighting the advancements, challenges, and prospects in this rapidly evolving field.

Detection techniques for abnormal lung conditions for COVID-19, pneumonia, cancer, and TB have evolved significantly over the years, leveraging advancements in medical imaging, molecular biology, AI diagnostic systems, and other technologies. Here's an overview of each condition:

- *COVID-19*: The coronavirus SARS-CoV-2, which appeared in late 2019, is responsible for a disease that quickly escalated into a worldwide pandemic. It primarily affects the respiratory system, leading to symptoms such as fever, cough, and difficulty breathing. Diagnostic methods for COVID-19 include real time Reverse Transcription – Polymerase Chain (RT-PCR) tests for viral Ribonucleic Acid (RNA) detection, antigen tests for viral proteins, and imaging techniques like chest X-rays and computed tomography (CT) scans to identify characteristic lung abnormalities. As of 2024, there have been 704,753,890 confirmed cases of COVID-19 worldwide, with 7,010,681 deaths. The incidence and mortality rates vary across different regions and demographics [2].

- *Pneumonia*: Pneumonia is an inflammatory condition of the lungs, typically caused by bacterial, viral, or fungal infections. It can lead to symptoms such as cough, fever, and difficulty breathing. Diagnosis of pneumonia involves clinical evaluation, chest X-rays, CT scans, and laboratory tests such as sputum culture or blood tests to identify the causative pathogen. Pneumonia is a major contributor to illness and death globally, especially affecting children under five and the elderly. According to the WHO, pneumonia accounts for approximately 2.5 million deaths annually [3].

- *Tuberculosis*: TB spreads through the air when an infected person coughs or sneezes. Diagnosis of TB involves clinical evaluation, chest X-rays, sputum smear microscopy, Nucleic Acid Amplification Tests (NAATs), and culture-based methods to isolate the bacteria. TB is a global health threat. According to WHO, approximately 10 million tuberculosis cases and 1.4 million deaths were registered worldwide [4].

1.1 Relevance and Problem Definition

The proposed model have significant relevance with the field of healthcare and medical diagnostics. Some key points, highlighting its importance include early detection, reducing misdiagnosis, and effective diagnosis. The proposed model can transform the diagnostic practices and enhance patient care. Hence, the model addresses the global health challenges of lung diseases. It represents a promising intersection of healthcare, technology, and innovation, with the potential to make a profound impact on individual's life and public health on a broader scale.

The motivation is rooted in addressing the issue of rising healthcare costs as DL-based diagnostic tools can help streamline healthcare processes, potentially reducing costs for both patients and healthcare providers and helping with global health crises. Events such as the COVID-19 pandemic have highlighted the need for innovative and efficient diagnostic tools. DL-based diagnostics can enhance our preparedness for future health crises. Lung abnormalities, including cancer, pneumonia, TB, COVID-19, and other infections, are a significant public health concern. The timely and accurate detection of such abnormalities plays a crucial role in improving patient's recovery. Traditional diagnostic methods, based on manual interpretation of medical images like X-rays and CT scans, are time-consuming and may be subject to errors due to human factors. This work aims to develop a DL-based solution to address these challenges. Following are the objectives of the proposed model:

- *Automated Detection*: To develop a robust DL model capable of automatically detecting abnormal regions in lung images. This includes identifying tumors, nodules, or areas of infection.

- *Diagnostic Accuracy*: The model focuses on improving diagnostic accuracy by reducing the risk of human error in the interpretation of medical images. DL models are expected to provide consistent and precise results.

- *Large-Scale Analysis*: Healthcare institutions generate vast amount of medical image data daily. The DL model will efficiently analyze large datasets, making it feasible to diagnose lung abnormalities more rapidly than traditional manual examination.

- *User-Friendly Interface*: The DL model will be integrated into a user-friendly interface that is accessible to healthcare professionals and minimizes the need for extensive training.

1.2 Major Contributions

- An automated DL based model is proposed to predict early abnormalities of the lung that causes major and dangerous diseases like cancer, COVID-19 and TB.
- This work uses dense connectivity pattern based on Dense Convolutional Network. Here, each layer is connected to every other layer in a feed-forward fashion. This dense connectivity facilitates feature reuse and helps alleviate the vanishing-gradient problem. Hence, accuracy of the model is increased.
- Matthews Correlation Coefficient is used to predict large amount of imbalanced data. This provided deep learning of the abnormal structures of lung if affected by any disease.

2. Literature Survey

In recent years, DL techniques have shown promising outcomes in detecting abnormal lung structures associated with various diseases. This section explores various DL techniques employed for the detection of lung abnormalities in chest X-rays. The focus lies on four specific lung diseases: pneumonia, COVID-19, lung cancer, and tuberculosis.

For Pneumonia and COVID-19, in one study, the focus was on its detection using chest X-rays, employing logistic regression and a DenseNet-based deep learning model [5]. Although the deep learning model outperformed logistic regression slightly, the study emphasized the need for larger and more diverse datasets to enhance model performance effectively**.** Another study addressed the urgent need for efficient disease detection in the context of COVID-19 by proposing a CNN-Long Short-Term Memory (LSTM) approach for automatic COVID-19 diagnosis from X-rays [6]. In one study, the authors achieved a three-way classification (normal, pneumonia, COVID-19) with an impressive accuracy of 0.995 for COVID-19 detection using a combined Xception-ResNet50V2 network on a substantial dataset of over 11,000 images. Their innovative neural network achieved remarkable accuracy in detecting COVID-19 cases and demonstrated high performance across all classes, underlining its real-world effectiveness [3, 7]. Deep-CNN and Large-scale chest X-ray (ChestX-ray8) databases are also explored and used for weakly supervised learning for localizing disease regions in X-ray images. The ResNet (50 layers) gave better results than AlexNet, GoogleNet, Visual Geometry Group (VGG) model [8].

Research has also explored DL for lung cancer detection. One study utilized CT scans and a novel Fuzzy Particle Swarm Optimization (FPSO) based CNN for cancerous nodule localization and classification, demonstrating effectiveness and reduced computational complexity compared to other techniques [9]. In [10], DL combined with a genetic algorithm for lung nodule classification as malignant or benign, achieving promising results without explicit shape and texture feature computations. For lung cancer detection using CT scans, DL methods have been employed to localize cancerous nodules and classify cancer severity. Research utilizing FPSO-based CNN showcased superior performance in classification while optimizing computational complexity, representing a significant advancement in lung cancer detection.

Addressing TB, the DL techniques have been applied to improve TB detection from chest X-ray images, using a combination of deep learning, and segmentation [11]. By enhancing image quality through specific algorithms and employing transfer learning with pre-trained models, researchers achieved promising results in TB diagnosis, even with challenging image conditions. DL is also explored for the detection of tuberculosis patterns in chest X-ray images, demonstrating the feasibility of using DL for TB pattern detection [12].

The detailed study of detection techniques for pneumonia, COVID-19, lung cancer, and tuberculosis is carried out and a review is published in [13]. Readers can refer [13] for detailed literature review of the proposed model. The study infer that optimization of analysis of medical images can enhance the accurate detection of lung abnormalities. DL is popularly used as the model has mathematical background of convolution theory to support precise predictions.

3. Proposed Method

In this section, the procedural aspects required for DL model implementation is explained in detail. The dataset referred, data preparation, CNN architecture, parameters for data analysis, optimization methods and model saving procedure is explained as following:

3.1 Dataset

Here the datasets used for modeling are medical images indicating lung conditions, which are used to detect COVID-19, pneumonia, TB, and normal condition. The Covid-19 radiography database is made by a team of researchers from Qatar and Bangladesh. The dataset used for our study includes COVID-19 cases, both positive and negative, lung opacity cases, and pneumonia cases [14].

Similarly, a team of researchers from Qatar and Bangladesh, along with collaborators from Malaysia, developed the Tuberculosis (TB) Chest X-ray Database. This database contains chest X-ray images of both TB-positive cases and normal cases. There are 700 TB images publicly accessible and 2800 TB images [15].

3.2 Data Preparation

Data preparation was carried out for all the images as shown in Fig. 1. It consists of four steps as follows:

a. Increasing the contrast of all images using Histogram Equalization. This normalizes the intensity of images from different datasets.
b. Removing the noise from all images using Median Filtering with a window size of 3 × 3.
c. Resizing images to 28 × 28 pixels to match the input of the model used.
d. Normalizing image color based on mean and standard deviation of the ImageNet training set [16].

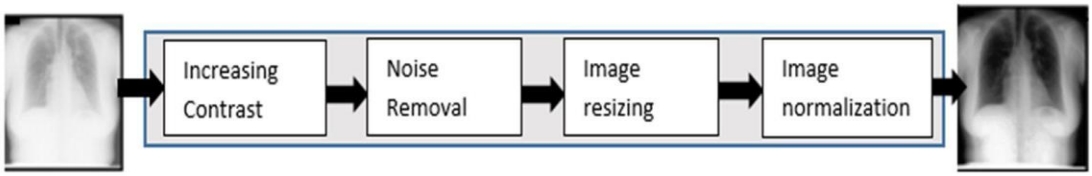

Fig 1. Data preparation process on an image [16]

3.3 CNN Architecture

Among all the convolutional neural network architectures like ResNet [17], and DenseNet [18], the model used in this research is the 121-layer Densely Connected Convolutional Networks (DenseNet-121) [19]. DenseNet stands for Dense Convolutional Network, and it's known for its dense connectivity pattern. In a DenseNet, each layer is connected to every other layer in a feed-forward fashion. This dense connectivity facilitates feature reuse and helps alleviate the vanishing-gradient problem.

3.3.1 DenseNet

Deep Convolutional Networks (DCNNs) have become one of the most sought-after frameworks because of the deep convolutional and pooling layers [20]. DenseNet is a kind of CNN with dense feature connection that ensures complex information flow between its various layers [21]. The provided model employs transfer learning with DenseNet, a widely used pre-trained model for image classification tasks. DenseNet is chosen as the initial layer

within a Sequential model, serving the purpose of feature extraction. Unlike traditional architectures, DenseNet's dense connections between layers promote effective feature reuse and gradient flow during training. Following the DenseNet layer, a flattened layer is introduced to convert the multi-dimensional feature maps into a one-dimensional array, preparing them for input into subsequent fully connected dense layers.

In this implementation, four dense layers are sequentially stacked, progressively reducing dimensionality while augmenting the number of parameters. Each dense layer incorporates ReLU activation, enabling the model to learn intricate patterns and representations. The final dense layer is outfitted with softmax activation, generating probabilities for each class in the classification task. This ensures that the output values are appropriately normalized to represent class probabilities. The model summary provides comprehensive insights into its architecture, including the types of layers employed, their respective output shapes, and parameter counts. Notably, non-trainable parameters encompass the weights of the pre-trained DenseNet model, meticulously preserved during training to prevent their modification. In essence, this implementation harnesses transfer learning with DenseNet to proficiently extract features from input images, facilitating efficient classification. Such a strategy underscores a reliable methodology for leveraging pre-trained models in image classification tasks, thereby facilitating precise and effective outcomes.

The algorithm for implementing DenseNet architecture is as follows:-

Step 1: START

Step 2: Use a pre-trained convolutional base.

Step 3: Use the Flatten layer to convert the output of the convolutional base to a one-dimensional tensor.

Step 4: Create several densely connected layers with ReLU activation.

Step 5: Select an output layer with softmax activation for multi-class classification

Step 6: Choose the stochastic gradient descent optimizer and Adam optimizer to select the appropriate learning rate

Step 7: Train the model for 20 epochs

Step 8: END

3.4 Parameters

These parameters are commonly used metrics for evaluating the performance of classification models, particularly in the context of binary or multiclass classification tasks. Here's a brief explanation of each parameter:

a. *Precision*: A system is said to be precise if the system model produces accurate positive predictions. It is the ratio of the number of positive predictions of positive cases to the sum of positive and negative predictions of positive cases. Precision is crucial when the number of negative predictions is high [22]. In this context, the precision scores are 1 for COVID-19, 0.98 for pneumonia, 0.97 for tuberculosis, and 0.88 for normal images.

b. *Recall*: Also referred to as sensitivity, recall measures how effectively the model identifies all positive instances. It is crucial when it's important to capture all positive instances, even at the cost of some false positives. It is 0.88 for Covid-19, 0.95 for pneumonia, 0.98 for TB, and 0.99 for normal images [22].

c. *F1 score*: Precision considers all positive cases' predictions for precise results. Recall considers both positive and negative cases' predictions effective results. The F1 score is calculated by combining both precision and recall to have efficient output. It is the harmonic mean of both parameters. It is useful for evaluating models on imbalanced datasets where the class distribution is skewed [22]. Here it is 0.94 for COVID-19, 0.96 for pneumonia, 0.98 for TB, and 0.94 for normal images.

d. *Support*: Support indicates the number of occurrences of each class in the dataset. It provides insight into the distribution of classes and helps in understanding the reliability of the evaluation metrics. Classes with low support may indicate data imbalance or scarcity. It is 724 for COVID-19, 278 for pneumonia, 723 for normal, and 131 for TB.

e. *Matthews Correlation Coefficient*: The Matthews Correlation Coefficient (MCC) is a metric used in machine learning to assess the performance of binary classification models, especially when handling imbalanced datasets. The MCC considers the positive prediction of the positive case, positive prediction of the negative case, negative prediction of the positive case, and negative prediction of the negative case. Its value ranges from -1 to 1, where 1 signifies a perfect prediction, 0 signifies a random prediction, and -1 signifies complete disagreement between

prediction and observation [23]. Here, the positive prediction of negative cases and the negative prediction of positive cases are both risky outcomes because they will initiate an ill diagnosis of the patient. The formula for MCC is represented in Eq. 1.

$$MCC = \frac{PN \times PP - NN \times NP}{\sqrt{(PP+NP)(PP+NN)(PN+NP)(PN+NN)}} \quad \text{Eq. (1)}$$

where PP is a positive prediction for a positive case, PN is a positive prediction for a negative case, NP is a negative prediction for a positive case and NN is a negative prediction for a negative case.

3.5 Optimization Method

Optimization methods are fundamental components of training machine learning models. These methods are responsible for adjusting the parameters of the model iteratively during training to minimize a defined loss function. The objective is to find the optimal set of parameters that best fit the training data and generalize well to unseen data. In the provided code snippet, various optimization methods, and callbacks are implemented for training a neural network model using TensorFlow's Keras API. Here's an explanation of each component:

a. *Stochastic Gradient Descent (SGD)*: The SGD optimizer is imported from tensorflow.keras.optimizers. SGD is a popular optimization algorithm used to minimize the loss function during training by updating model parameters in a direction that reduces the loss [24]. In this implementation, SGD is configured with a learning rate of 0.01.
b. *Checkpoint Callback*: A checkpoint callback is created using ModelCheckpoint. This callback saves the model's weights during training at specific intervals or conditions [25]. In this case, the callback is configured to save only the weights (save_weights_only=True) to the specified checkpoint path (checkpoint_path). Additionally, verbose=1 indicates that progress updates will be displayed during training.
c. *Early Stopping Callback*: Another callback, EarlyStopping, is instantiated to monitor the validation loss during training. Early stopping prevents overfitting [26]. Parameters such as patience, min_delta, and restore_best_weights are provided to control the early stopping behavior. In this case, training will halt if the validation loss does not improve for 10 consecutive epochs (patience = 10), with a minimum required improvement of 0.001 (min_delta = 0.001). The restore_best_weights parameter ensures that the model's weights are restored to the best-performing ones on the validation set.

3.6 File format to save the model

The implementation includes functionality to save the trained model in HDF5 (.h5) format. The HDF5 format is a hierarchical data format commonly used for storing and managing large numerical datasets. In the context of deep learning, it serves as a standard format for saving and loading trained models in Keras. The .h5 file contains the model architecture, including the configuration of layers, as well as the trained weights and biases. Saving the model in HDF5 format allows for seamless reuse and deployment of the trained model in various applications, including further training, inference, and transfer learning.

3.7 Model Implementation

In this work, after training and evaluating the model, it is saved in both HDF5 and TensorFlow Lite formats using the model.save() function. The HDF5 format preserves the entire model architecture and weights, facilitating further analysis and modification if needed. On the other hand, the TensorFlow Lite conversion process involves additional steps to optimize the model for deployment on mobile and edge devices. This typically includes quantization (reducing the precision of weights and activations), pruning (removing unnecessary operations and parameters), and other optimizations tailored to the target platform.

a. *Data Preparation*: The code begins by downloading two datasets from Kaggle: the COVID-19 Radiography Database and the Tuberculosis (TB) Chest X-ray Dataset. These datasets contain chest X-ray images categorized

into different classes. The images are resized to a uniform size of 120x120 pixels and stored in lists along with their corresponding labels.

b. *Model Building*: The code constructs a deep learning model using transfer learning. Different pre-trained convolutional neural network (CNN) architectures, including VGG16, EfficientNetB0, EfficientNetB7, and ResNet50, are utilized as feature extractors. A fully connected neural network with dense layers is then added on top of the pre-trained CNN for classification. The model is compiled with various optimizers such as Adam and SGD, and the loss function is set to categorical cross-entropy.

c. *Model Training*: The training data is split into training, validation, and test sets using the train_test_split function. The model is trained on the training data with a specified batch size and number of epochs. Early stopping and model checkpoint callbacks are used to prevent overfitting and save the best model weights during training.

d. *Model Evaluation*: After training, the model is evaluated on the test set to assess its performance in terms of loss and accuracy. Additionally, classification metrics such as precision, recall, F1-score, support, and the Matthews correlation coefficient are calculated. A confusion matrix is generated to visualize the classification results.

e. *Results Visualization*: The predictions made by the model on the test set are visualized along with the corresponding actual labels using *matplotlib*. The model's training and validation accuracy and loss curves are plotted to analyze its training dynamics.

4. Results & Discussion

The architecture of the deep learning model is visualized using the plot_model function from Keras, which generates a graphical representation of the model's layers and their connections. Overall, the model demonstrates the end-to-end process of building, training, evaluating, and visualizing a deep learning model for chest X-ray image classification. The use of transfer learning with pre-trained CNN architectures allows for efficient feature extraction and classification, enabling the model to achieve high accuracy in identifying various chest diseases. The performance of the model in this study was evaluated using accuracy, precision, recall, F1-score, and support. The accuracy shows the degree to which the model correctly identified both positive and negative cases. The precision is a metric that measures the proportion of positive identifications that are correct. The Recall is a metric that measures how often a machine learning model correctly predicts the outcome. The F1 score is a metric in machine learning that evaluates a model's performance by balancing both precision and recall. The MCC for the given model is determined to be 0.9166. Table 1 displays the model testing parameters' scores for corresponding diseases using a multi-class single-stage classifier. The overall accuracy obtained for the model was 0.91.

Table 1 Model performance evaluation using various performance metrics

Disease	Precision	Recall	F1 Score	Support
Covid-19	1	0.88	0.94	724
Normal	0.88	0.99	0.94	723
Pneumonia	0.98	0.95	0.96	278
Tuberculosis	0.97	0.98	0.98	131

Fig 2. Class wise performance comparison

Figure 2 depicts the graph of performance comparison using Precision, Recall and F1-score for Covid-19, Pneumonia, Tuberculosis and Normal classes. In Table 2, confusion matrix representing overall predictions is shown when evaluated using the testing data. Maximum value obtained on the diagonal of the matrix indicates the low error of the system and the model's efficiency to correctly identify the disease based on the x-ray image provided.

The model accuracy and model loss evolving with the progression of epochs during training and testing is measured and the graph is represented in Fig. 3. The trained dataset is compared with test data and the nature of the graph of test data is similar to that of trained data.

Table 2 Confusion Matrix

	Covid-19	Normal	Pneumonia	Tuberculosis
Covid-19	639	79	2	4
Normal	1	718	4	0
Pneumonia	0	15	263	0
Tuberculosis	2	0	0	129

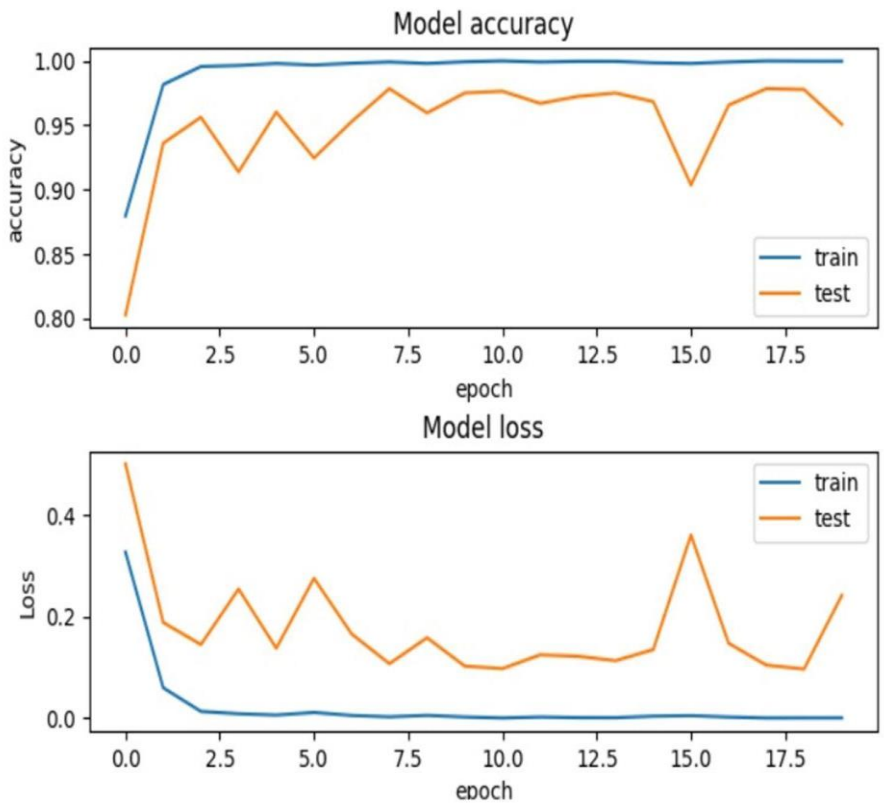

Fig 3. Model accuracy and model loss evolving with the progression of epochs during training and testing

Here, it is evident that the accuracy for the training data steadily increases with epochs and reaches saturation after a time. On the testing data, the accuracy takes an uneven course of path and forms local maximas and minimas.

From this optimal number of epochs for maximum accuracy of our model can be figured out. This illustrates class wise mean absolute error and root mean square error using a line chart of Normal, Covid-19, Pneumonia and Tuberculosis classes.

In Fig. 4, the error observed class wise are compared. The parameters calculated are the mean absolute error and root mean square error. The actual result and predicted result of few X-ray images of lungs used for testing the model's performance are depicted in Fig. 5.

It is seen that the model works efficiently, providing correct predictions as per the actual results. Hence, the proposed technique can be used for early detection of diseases.

Through this analysis, it is determined that the model achieved an accuracy of 94.23%. It means that the model accurately predicted the diagnosed disease of the lungs (if any) 9.423 out of 10 times.

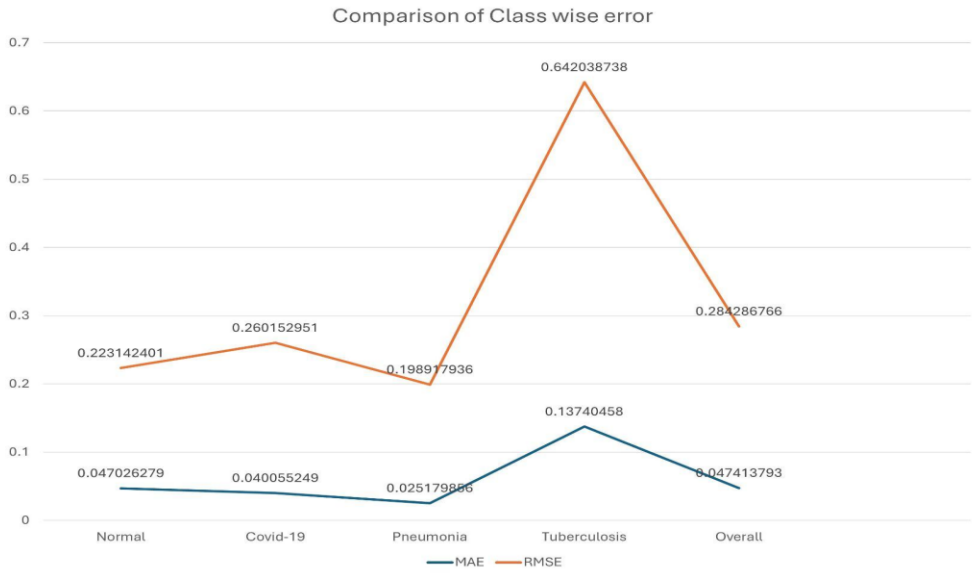

Fig 4. Class wise error comparison (mean absolute error and root mean square error)

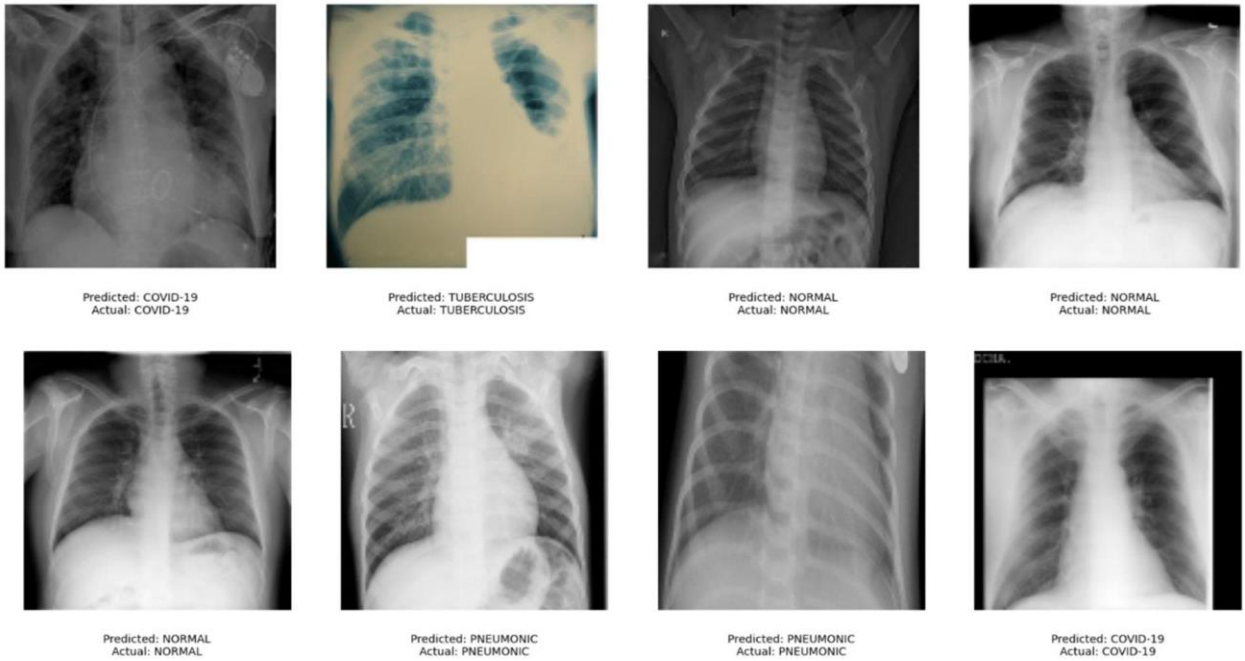

Fig 5. The predicted and actual results of images in the testing dataset

5. Conclusion

The model's ability to accurately classify chest X-ray images has promising implications for assisting healthcare professionals in efficiently diagnosing and managing respiratory diseases. By leveraging advanced deep learning

techniques, this study contributes to the broader efforts aimed at leveraging technology to augment and improve medical diagnosis and patient care.

The proposed work showcases the development and evaluation of a deep learning model for classifying chest X-ray images into distinct disease categories. The model exhibits a test accuracy of approximately 94.23% and a test loss of 0.2664 on the training dataset. These metrics, along with precision, recall, and F1-score analyses, underscore the model's efficacy in discerning between various respiratory conditions. However, it is noted that certain classes, such as COVID-19 and Pneumonia, may pose challenges for the model, as indicated by lower performance metrics compared to other classes. This observation suggests potential biases or difficulties in distinguishing between specific disease categories, warranting further investigation and refinement of the model architecture.

Future research endeavors could focus on the integration of the developed model into real-world healthcare settings and conducting clinical validation studies. Also, the further refinement and validation if warranted, the findings of this study hold promise for enhancing the efficiency and accuracy of respiratory disease diagnosis through automated image analysis methodologies.

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Coder's Battle Room Using Cloud Computing

Sushmita Hubli [1], Sachin Ghuge [2] & Dr. S. V. Shinkar [3]

[1]Student; SCTR'S Pune Institute of Computer Technology, Department of Electronics and Telecommunication, Pune, Maharashtra, India, hublisushmita7@gmail.com
[2]Student; SCTR'S Pune Institute of Computer Technology, Department of Electronics and Telecommunication, Pune, Maharashtra, India, ghugesachin0806@gmail.com
[3]Assistant Professor; SCTR'S Pune Institute of Computer Technology, Department of Electronics and Telecommunication, Pune, Maharashtra, India, svshinkar@pict.edu

Abstract:

In the ever-evolving landscape of competitive programming and coding contests, the utilization of cloud computing has emerged as a transformative force, revolutionizing the way programmers participate and compete. This survey paper, titled "Coder's Battle Room Using Cloud Computing," explores the wide-ranging applications of cloud computing in coding competitions conducted across diverse online platforms. Coding contests have gained immense popularity, offering participants opportunities to showcase their problem-solving skills and coding acumen. With the increasing scale and complexity of these contests, cloud computing has provided an essential infrastructure to support the demands of both organizers and contestants. This paper provides a comprehensive overview of the key components and functionalities of cloud-based coding battle rooms discussion, shedding light on their architecture, advantages, and prospects. By examining the state-of-the-art practices in this field, this survey offers insights into how cloud computing is shaping the competitive coding landscape, facilitating global participation, and fostering innovation in algorithmic problem-solving. As the demand for coding contests continues to grow, understanding the symbiotic relationship between coding platforms and cloud computing becomes essential for both participants and organizers. This survey serves as a valuable resource for researchers, practitioners, and enthusiasts seeking to navigate the exciting realm of coding competitions in the cloud era.
Keywords: Cloud Computing, Competitive Programming, Contest Platforms, Data Structures and Algorithms, Online Platforms, Optimal approach.

1 Introduction

The world of competitive programming has undergone a profound transformation in recent years, ushering in a new era where algorithmic prowess and coding acumen are celebrated on a global scale. Coding contests, ranging from the fiercely competitive ACM ICPC (International Collegiate Programming Contest) to online platforms like Codeforces, LeetCode, and HackerRank, have become the crucibles in which the finest programmers refine their skills and showcase their problem-solving abilities. However, what sets apart this contemporary realm of competitive coding is the infusion of cloud computing, a technological phenomenon that has fundamentally reshaped the way these contests are orchestrated, experienced, and celebrated. In the not-so-distant past, coding contests were predominantly local affairs, often held within the confines of educational institutions or tech company campuses. Participants would assemble in physical spaces, armed with their trusty laptops, to engage in timed battles of logic and ingenuity. While these contests served as valuable breeding grounds for talent, they had inherent limitations-geographical constraints, limited computational resources, and logistical complexities, to name a few. Enter the era of serverless cloud computing a paradigm shift that has transcended boundaries and unlocked unprecedented potential in the world of coding competitions. Cloud computing involves accessing and utilizing various IT resources such as compute power, storage, databases, applications, and more via the Internet on a pay-as-you-go basis, allowing for on-demand consumption as needed [1]. In this survey paper, we embark on an insightful journey into the convergence of competitive coding discussion and cloud computing, illuminating the transformative impact this partnership has had

on the coding contest landscape. This study looks at online discussions from both static and dynamic angles. The outcomes show the features of group knowledge creation process online discussion in a blended learning environment. The benefits and drawbacks of this study can be utilized to raise the process of group knowledge building's efficacy [12]. Our journey in this survey paper begins by exploring the architectural underpinnings of the Coder's Battle Room. We dissect the various components and technologies that collaborate to provide participants with a seamless and exhilarating coding question discussion experience. From virtual machines and containerization to distributed computing clusters, the infrastructure supporting these digital arenas is a testament to the power and versatility of cloud computing. However, the allure of cloud-powered coding contests extends far beyond the mere convenience of virtual battlefields. It encompasses a multitude of advantages that have redefined the very nature of competitive programming. Universal accessibility is chief among them, as participants from diverse corners of the globe can engage in the same contest, levelling the playing field and fostering cross-cultural collaboration. Cost-effectiveness is another critical facet, as cloud resources are procured on-demand, eliminating the need for expensive on-premises hardware and infrastructure maintenance [21]. To truly understand the magnitude of this transformation, we will undertake an extensive exploration of the state-of-the-art platforms and technologies that are pushing the boundaries of what is possible in cloud-based coding contests. We shall embark on comparative analyses of these platforms, offering a critical assessment of their features, user experiences, and the innovations they bring to the table. Moreover, this survey paper will cast its gaze into the future. By discerning emerging trends and technological advancements, we aim to provide a glimpse of the evolving landscape of coding competitions in the cloud era. What new paradigms and tools will shape the contests of tomorrow? What research opportunities lie on the horizon? These are questions we shall strive to answer. In summation, this survey serves as a comprehensive guide for researchers, practitioners, educators, and coding enthusiasts who seek to navigate the captivating realm of coding contests as it stands today - a realm where cloud computing breathes new life into age-old competitions, redefining what is possible and paving the way for an exciting future of collaborative coding excellence on a global scale. Let us embark on this journey into the heart of the "Coder's Battle Room," where code becomes art, and the cloud empowers dreams.

2 Literature Survey

2.1 Evolution of Cloud Computing:

Cloud computing has progressed through several stages to meet varying needs. Early models such as Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) provided users with a broad range of control and flexibility. IaaS offered virtualized computing resources over the internet, allowing users to manage and configure their own virtual machines. PaaS, on the other hand, abstracted some of the infrastructure management, enabling developers to focus more on application development. However, these models often required significant management overhead and could lack flexibility for dynamically changing workloads. The advent of serverless computing marked a significant shift. Introduced with AWS Lambda in 2014, serverless computing provides a model where developers write code without worrying about the underlying infrastructure. Instead, resources are automatically scaled based on demand, and users are billed only for the compute time consumed by their functions. This shift promised greater efficiency and cost savings, making it particularly attractive for applications with highly variable workloads.

2.2 Serverless in Competitive Coding Platforms:

In the context of competitive coding platforms, serverless computing has shown promise due to its ability to handle unpredictable workloads without the need for pre-provisioned resources. Competitive coding platforms often experience spikes in activity during contests or high traffic periods, and serverless models are well-suited to scale dynamically in response to such spikes. Research has demonstrated that serverless architectures can manage these fluctuations effectively by automatically provisioning resources as needed. However, there are noted limitations, such as cold start latency, which can affect the responsiveness of the platform, and the constraints on execution time which

may not be suitable for tasks requiring long processing times. Despite these challenges, serverless computing's benefits in cost efficiency and scalability make it a compelling choice for many applications in this domain.

2.3 Comparative Studies:

Comparative studies highlight that serverless computing generally offers a cost-effective and efficient model, particularly for applications with unpredictable or highly variable demand. Serverless models operate on a pay-as-you-go basis, which can significantly reduce costs compared to maintaining a fixed set of servers.

This model is advantageous for applications that experience fluctuating workloads, as it eliminates the need for over-provisioning and ensures that users only pay for the resources they actually use. Nevertheless, ongoing challenges include security concerns, such as the need for robust mechanisms to protect function code and data, and the requirement for better management tools to monitor and control serverless environments effectively.

Despite these challenges, the evolution of serverless computing continues to drive innovation and efficiency, presenting new opportunities and considerations for developers and organizations.

3 Proposed Methods

AWS Lambda, Azure Functions, and Google Cloud Functions are serverless computing services provided by the respective cloud platforms. They allow developers to build, deploy, and run applications without managing the underlying infrastructure. Here's a detailed explanation of each:

A. AWS Lambda

AWS Lambda is offered by Amazon Web Services (AWS). It is a cloud service that lets developers run code without having to set up or manage any servers. In a serverless architecture, developers can focus solely on writing and deploying their functions, leaving the infrastructure, scaling, and maintenance tasks to AWS. Lambda functions are event-driven and can be triggered by various AWS services or HTTP requests.

They are written in languages like Python, Node.js, Java, and others, and can execute code in response to events such as changes in data, file uploads, or scheduled tasks. Lambda functions are stateless, meaning they don't retain information between executions, which promotes scalability and simplifies development. Developers pay only for the compute time consumed by their functions, making Lambda a cost-effective solution for running code in response to specific events.

Additionally, Lambda integrates seamlessly with other AWS services, enabling the creation of sophisticated, serverless architectures. Overall, AWS Lambda empowers developers to build scalable and efficient applications without the need to manage traditional server infrastructure.

B. Azure Functions

Azure Functions is a cloud service from Microsoft Azure that allows developers to build, launch, and expand apps without having to manage any servers. Function-as-a-Service (FaaS) is the core concept, allowing developers to focus solely on code logic rather than worrying about the underlying infrastructure.

Azure Functions provides support for multiple programming languages, such as C#, JavaScript, Python, and Java, giving developers a high degree of flexibility. Events like HTTP requests, database updates, scheduled timers, or messages from Azure services such as Azure Queue Storage or Azure Service Bus can trigger functions within Azure.

This event-driven model enables the creation of highly responsive and scalable applications, where functions are executed on-demand in response to specific events. Azure Functions are crafted to operate without retaining state and seamlessly integrate with additional Azure services like Azure Storage, Cosmos Database,

and Logic Applications. This seamless integration allows developers to build complex workflows and applications using a combination of serverless components.

The pay-as-you-go pricing model of Azure Functions ensures cost-effectiveness, as users are billed only for the resources consumed during the execution of functions. Additionally, Azure Functions provides robust monitoring and logging capabilities, allowing developers to track and troubleshoot issues efficiently.

The development experience is further enhanced with features like local debugging, continuous integration and deployment (CI/CD) support, and integration with popular development tools such as Visual Studio Code and Azure DevOps.

With its simplicity, scalability, and event-driven architecture, Azure Functions empowers developers to focus on writing code that delivers business value without the burden of managing infrastructure.

C. Google Cloud Functions

Google Cloud Functions is a cloud service from Google Cloud Platform (GCP) that lets developers create and launch functions that run automatically when triggered by events, and can scale up or down based on demand.

This serverless architecture eliminates the need for developers to manage infrastructure, enabling them to focus on writing code. Cloud Functions offers support for a variety of programming languages, such as Node.js, Python, Go, and Java, giving developers the flexibility to select their preferred language.

Developers can create functions triggered by various GCP services, such as Cloud Storage, Cloud Pub/Sub, and HTTP requests. These functions execute in lightweight, stateless containers, ensuring quick startup times and efficient resource utilization. Additionally, Cloud Functions integrates seamlessly with other GCP services, allowing developers to build complex workflows and applications by connecting different components of the Google Cloud ecosystem.

The pay-as-you-go pricing model ensures cost efficiency, as users only pay for the actual compute resources consumed during function execution. Monitoring and logging are built into Cloud Functions, enabling developers to gain insights into function performance, troubleshoot issues, and ensure reliability.

Launching is made easier using the gcloud command-line tool or through continuous integration/continuous deployment (CI/CD) pipelines.. Overall, Google Cloud Functions provides a scalable and efficient solution for building serverless applications, allowing developers to focus on writing code without the overhead of managing infrastructure.

Its integration with other GCP services and support for multiple programming languages make it a versatile choice for a wide range of applications and use cases.

4 Results & Discussion

4.1 Work Overview

In the "Coder's Battle Room using Cloud Computing" paper work, MongoDB Atlas Cloud was chosen as the database platform to store and manage information.

The focus of this image is on the structure and content of the database table for the questions. MongoDB is a NoSQL database system known for its flexibility and scalability, making it an ideal choice for cloud-based applications.

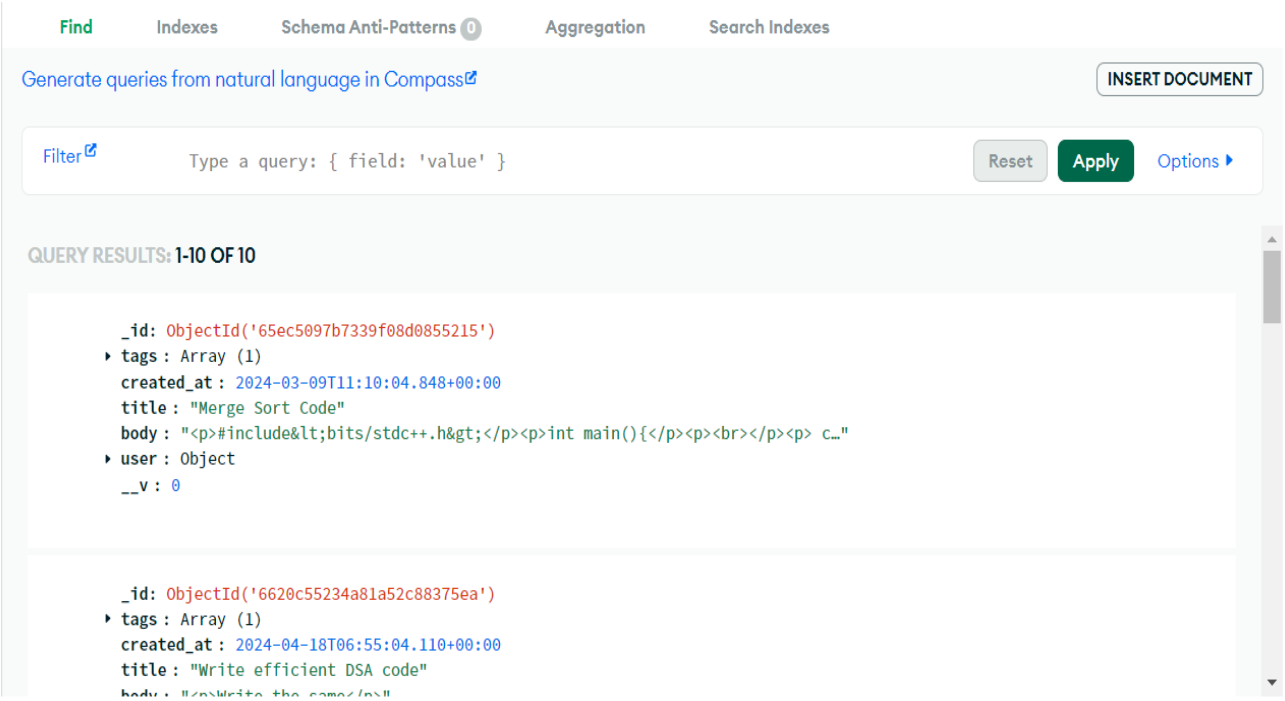

Fig. 1 Database content of Question table

The "Coder's Battle Room" work stores questions in MongoDB Atlas Cloud, using a flexible structure with key fields like "_id" "tags," "created_at," "title," "body," and "user" The "user" field establishes a link to the user collection, enabling connections between questions and their authors.

Indexes on fields like "_id" and "tags" optimize query performance, ensuring fast retrieval. Data management and security are addressed through role-based access controls and regular backups. MongoDB's scalability and flexibility support the platform's growth, allowing it to adapt to a larger user base without compromising performance. This setup provides a solid foundation for a reliable and scalable DSA discussion platform.

We have also created additional tables to support various interactions on the platform. The "comments" table stores comments that users post on specific questions submitted by others, allowing for deeper engagement and discussion.

The "answers" table is designed to capture user responses to questions, with each answer linked to a specific question ID for easy retrieval and organization. Similarly, the "posts" table holds information about articles and other content that individual users contribute to the platform, enabling a broader scope of user-generated content.

These tables work together to foster a robust and dynamic environment for discussion, feedback, and content sharing within the "Coder's Battle Room."

The work has resulted in the development of a fully functional platform where users can engage in discussions, post questions, provide answers, publish articles, and collaborate on problem-solving.

The platform's intuitive interface and comprehensive feature set cater to the diverse needs of users, enabling seamless interaction and knowledge sharing.

The platform can make a significant impact on the programming community by democratizing access to knowledge, fostering collaboration, and empowering individuals to improve their problem-solving skills and advance their careers.

By providing a supportive and inclusive environment for learning and growth, the platform has contributed to the professional development of countless users.

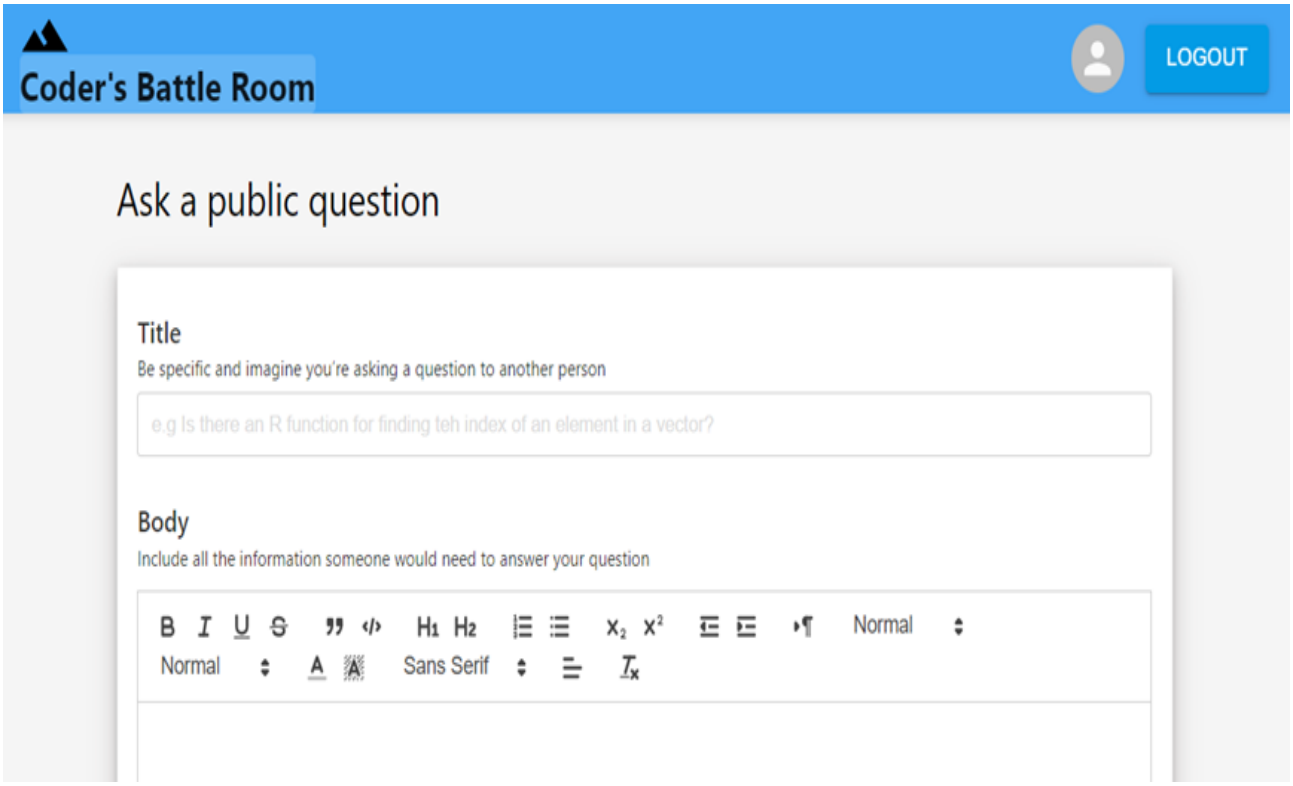

Fig. 2 Question Post Page

The above image shows the Question posting page of the platform, where users can ask questions and seek help from the community. Users can enter a clear title summarizing their question, provide details in the body section, and add relevant tags to categorize their query.

This setup ensures that questions are easily understandable and discoverable by others with similar interests or expertise. Overall, the Question posting page aims to simplify the process of seeking assistance and foster meaningful interactions among users within the platform.

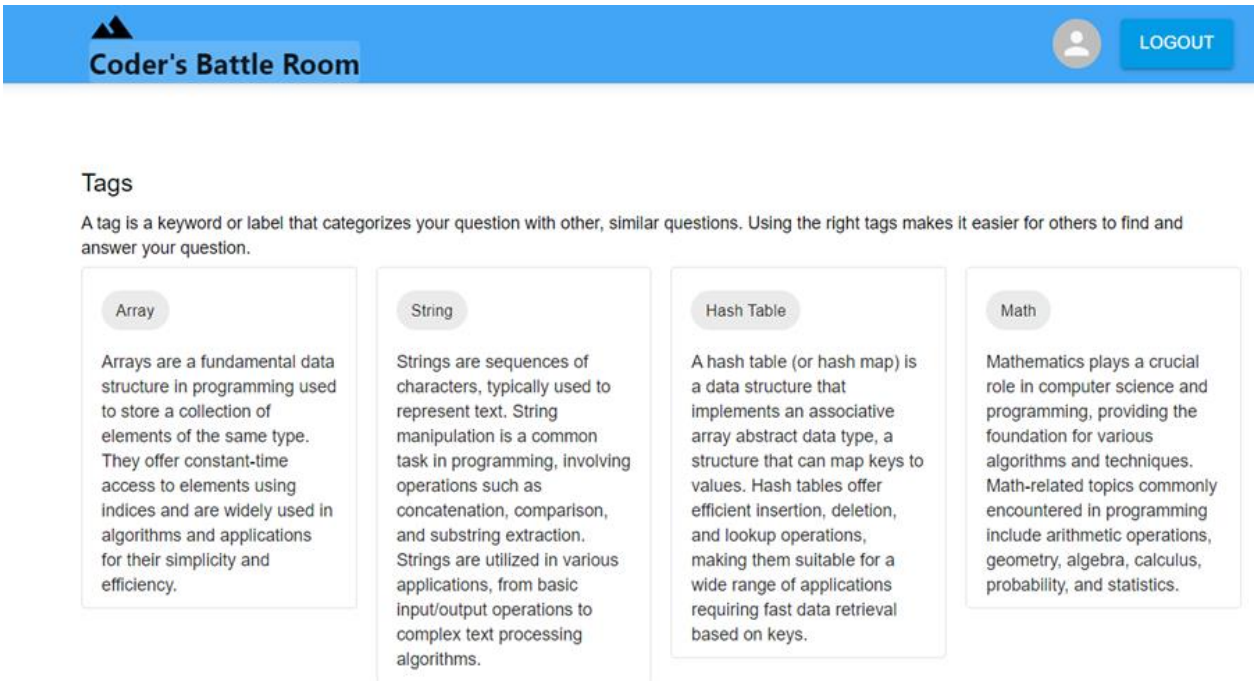

Fig. 3 Tags Information Page

The above tags page of the platform displays a list of tags used to categorize questions and topics discussed within the community. Users can explore various tags to find questions related to specific subjects or topics of interest.

By organizing questions into distinct categories, the tags page helps users navigate the platform efficiently and discover relevant content aligned with their interests and expertise. Overall, the tags page serves as a valuable resource for users to explore, engage, and contribute to discussions within the platform.

The articles page of the platform showcases a collection of diverse articles written by users on various topics related to data structures, algorithms, and competitive programming.

Users can explore these articles to gain insights, learn new concepts, and stay updated on the latest trends and developments in the field. Each article offers a unique perspective or tutorial, covering a range of subjects such as algorithm optimization techniques, programming language tips, and problem-solving strategies.

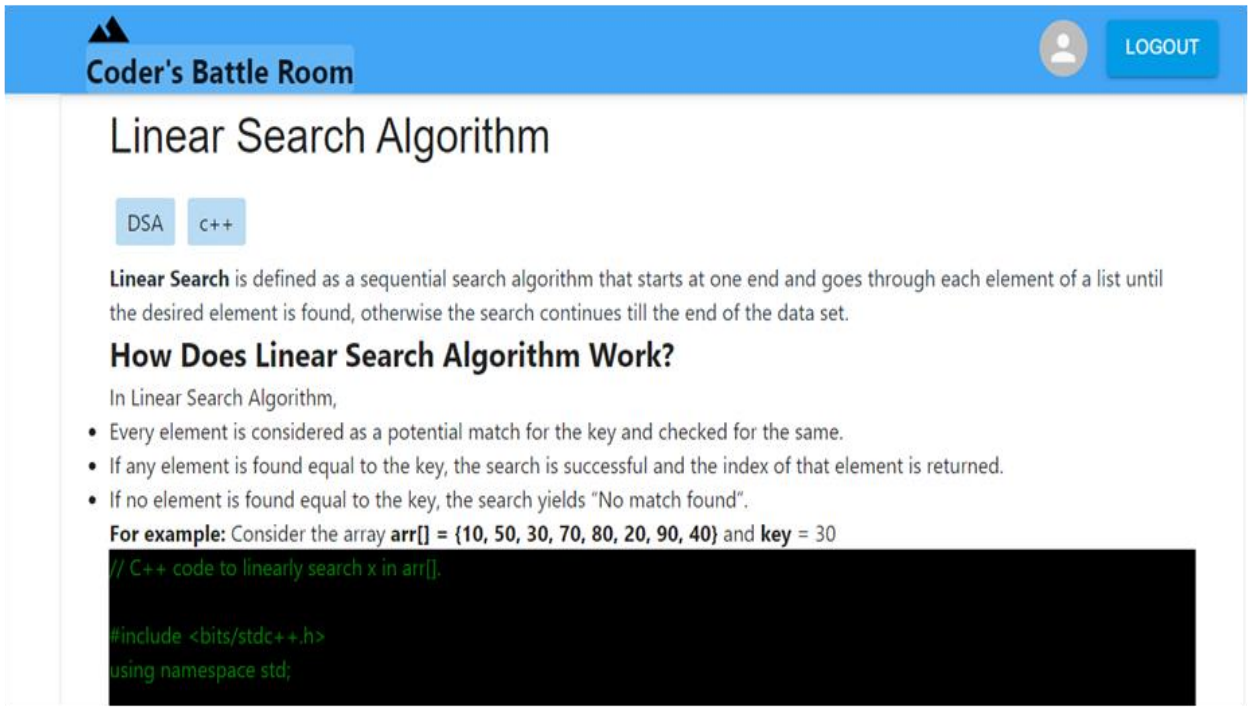

Fig. 4 Articles Page

By providing a platform for users to share their expertise and experiences through articles, the platform fosters knowledge sharing and collaboration among members of the programming community. Overall, the articles page serves as a valuable repository of educational resources and insights, enriching the learning experience for users and contributing to the collective knowledge base of the platform.

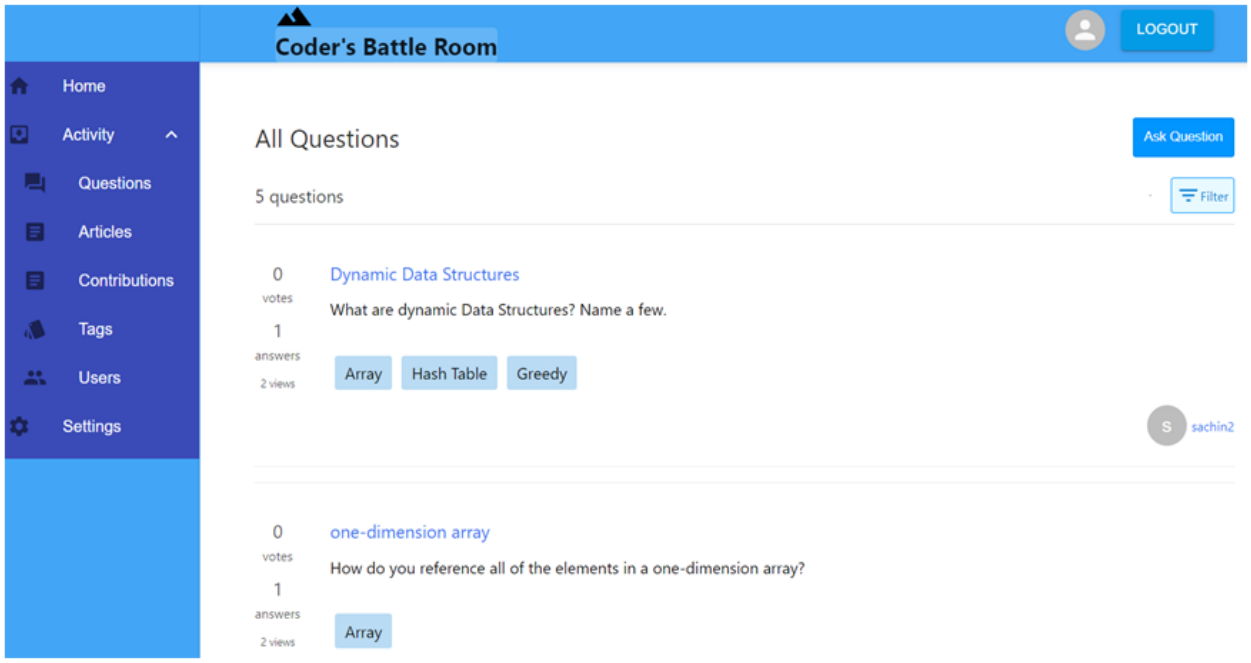

Fig. 5 Home Page

The home page of the platform serves as the central hub where users can explore a curated selection of questions posted by the community. Alongside these questions, users have access to convenient navigation options, including settings, user contributions, and articles. The user contributions section provides users with insights into their own contributions, including questions asked, answers provided, and articles published, fostering a sense of ownership and engagement within the community. Additionally, the articles section offers users a gateway to explore a wealth of educational resources and insights shared by fellow users, enriching their learning journey. Overall, the home page serves as a welcoming and informative entry point to the platform, empowering users to engage, contribute, and learn within the vibrant programming community.

4.2 Equations

Cloud computing involves various mathematical concepts and equations, primarily related to the areas of resource allocation, scalability, and performance optimization. Here are some mathematical equations and concepts commonly used in cloud computing:

• Elasticity refers to the ability of a cloud system to adapt to workload changes. The elasticity equation can be represented as:

$$\textbf{Elasticity} = \textbf{Change in Time}/\textbf{Change in Quantity} \quad (1)$$

• Scalability measures the ability of a system to handle an increasing amount of load or demand. It can be expressed as:

$$\textbf{Scalability} = \textbf{Change in Resources}/\textbf{Change in Performance} \quad (2)$$

• Resource utilization is the ratio of the actual usage of resources to the total available resources. It can be calculated using the formula:

$$\textbf{Resource Utilization = (Total Available Resources/Actual Resource Usage) X 100\%} \quad (3)$$

• Cloud computing involves costs, and optimizing these costs is crucial. The cost optimization equation can be represented as:

$$\textbf{Cost Optimization=Cost/Performance} \quad (4)$$

• Service Level Agreement compliance is essential to ensure that the cloud service meets the agreed-upon performance metrics. It can be calculated as:

$$\textbf{SLA Compliance} = (\textbf{Total Number of Requests / Number of SLA Compliant Requests}) \times \textbf{100}\% \quad (5)$$

• Response time is a critical performance metric. It can be calculated using Little's Law:

$$\textbf{Response Time = Request Arrival Rate / Number of Requests} \quad (6)$$

• Availability is a key metric for assessing the reliability of a cloud service. It is frequently represented as a percentage and determined by the following calculation:

$$Availability = (Total\ Time\ /\ Total\ Uptime) \times 100\% \quad (7)$$

• Throughput measures the amount of data transferred successfully over the network in a given period. It can be calculated as:

$$Throughput = Total\ Time\ /\ Total\ Data\ Transferred \quad (8)$$

4.3 Figures

AWS Lambda utilizes different cloud services available within the AWS ecosystem. Lambda functions can be triggered by various activities, including image uploads, in-app actions, website interactions, data from connected devices, or custom requests. Amazon Web Services has emphasized AWS Lambda's goal of eliminating the need for provisioning or managing virtual servers and its ability to automatically scale across multiple geographic regions (Availability Zones).

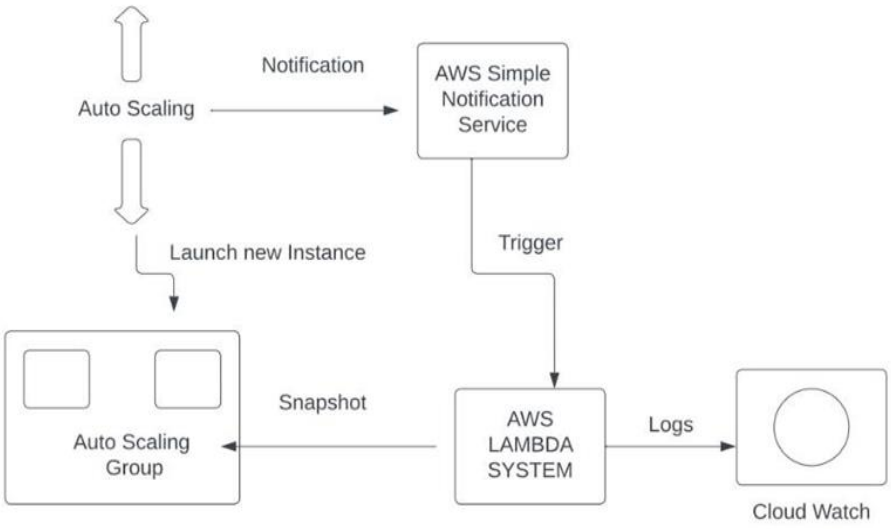

Fig. 6 AWS Lambda Demonstration

Amazon Web Services has highlighted numerous applications for AWS Lambda, including tasks such as real-time file processing, stream processing, Extract, Transform, Load (ETL) operations, and the creation of serverless backends for IoT, mobile, and web applications are supported.

Notable users of AWS Lambda include renowned companies like Netflix, SPS Commerce, Earth Network, Vidroll, Localytics, Seattle Times, Zillow, Bustle, and Major League Baseball Advanced Media.

These companies leverage serverless computing for diverse purposes including transcoding, monitoring, disaster recovery, compliance, data processing, sensor data analysis, real-time ad bidding, stream analytics, image resizing, mobile metrics tracking, and backend operations for mobile and web applications [8].

In the realm of serverless computing, cloud service providers take on the responsibility of managing the data center, servers, and runtime environment. Unlike other cloud models, serverless computing shifts more of the management and maintenance burden onto the cloud service provider, thereby relieving developers of these complexities [3].

Key characteristics of serverless computing include autoscaling, where functions scale automatically based on demand, allowing applications to handle a high volume of requests efficiently. Additionally, developers benefit from fast and independent deployment, as they can deploy or redeploy individual serverless functions without impacting the entire system. This level of independence in deployment surpasses that of microservices. Furthermore, serverless computing eliminates infrastructural costs associated with traditional cloud services, as companies only pay for the resources used rather than maintaining generously large machines to ensure availability [1][2][3].

Fig. 7(a) Contrast between Serverless Cloud Computing and Traditional Server-Based Approach

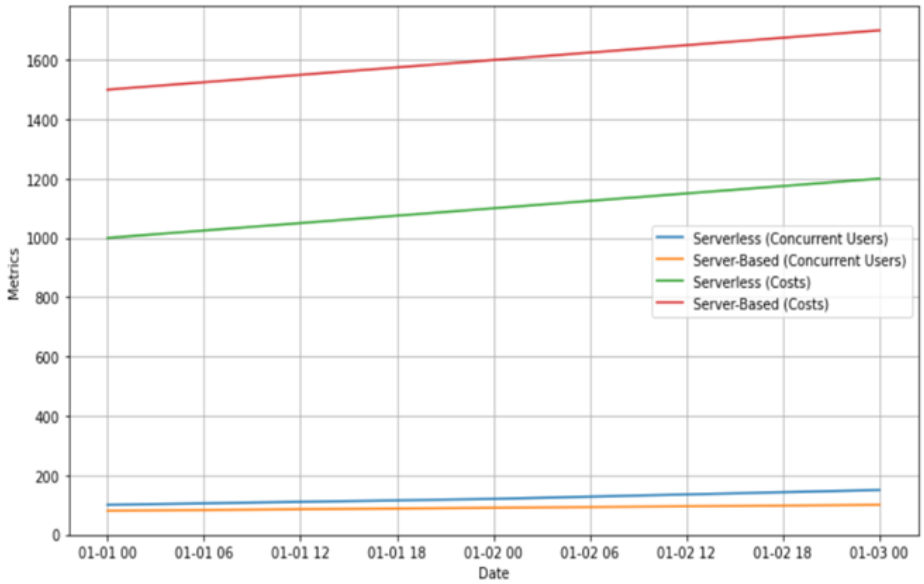

Fig. 7(b) Contrast between Serverless Cloud Computing and Traditional Server-Based Approach

Serverless cloud computing and server-based approaches offer distinct advantages and considerations across several factors. Regarding concurrent users, serverless computing typically excels due to its automatic scaling capabilities, efficiently managing fluctuating workloads without manual intervention. This scalability also translates into cost-effectiveness, as serverless models often operate on a pay-as-you-go basis, minimizing expenses during periods of low traffic compared to maintaining dedicated servers. However, while serverless computing reduces upfront infrastructure costs, it may lead to higher operational costs depending on usage patterns [1]. On the other hand, server-based approaches may involve greater management overhead, requiring manual provisioning, monitoring, and maintenance of servers. In contrast, serverless platforms abstract much of this management burden, allowing developers to prioritize the application's logic. Ultimately, the decision between serverless and server-based approaches depends on the specific requirements, workload characteristics, and budget considerations of each project [13][25].

5 State-of-the-Art Comparison

In this section, we compare key cloud computing models—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Serverless Computing (FaaS)—to understand their suitability for dynamic applications like competitive coding platforms.

- **Performance & Scalability:** IaaS requires manual scaling but offers full control. PaaS has built-in scaling, but may struggle with high variability. Serverless (FaaS) provides automatic scaling, making it ideal for fluctuating workloads.
- **Cost Efficiency:** IaaS can be costly due to the need to maintain idle resources. PaaS reduces management costs but may still be expensive with fluctuating demand. Serverless is cost-effective for variable workloads, charging only for actual usage.
- **Flexibility & Ease of Use:** IaaS offers maximum flexibility but at the cost of complexity. PaaS simplifies management but limits customization. Serverless is the easiest to use, with no infrastructure management required, though it may be less flexible for long-running processes.
- **Security & Compliance:** IaaS provides strong security but requires user management. PaaS includes built-in security features but offers less control. Serverless abstracts security, which is managed by the provider, potentially complicating compliance.

Summary: Serverless computing emerges as the most suitable for dynamic, real-time applications due to its scalability, cost efficiency, and ease of use, though the choice ultimately depends on specific application requirements.

6 Conclusion

In this thorough examination, we have explored the utilization of cloud computing to enhance the speed, scalability, and reliability of websites. The integration of cloud computing into the competitive coding arena through a specialized problem discussion platform is not just a novel concept; it represents a strategic advancement that enhances the coding experience. This integration empowers a global community of coding enthusiasts to collaborate, learn, and excel, thereby fostering progress and excellence in the field. Looking ahead, the ongoing development of this platform holds the promise of fostering collaboration and innovation in the continuously expanding domain of competitive coding.

Throughout our exploration, we have embarked on a journey to uncover the transformative potential of a cloud-powered problem discussion platform within the realm of competitive coding. We commenced by recognizing the dynamic nature of coding competitions, which draw participants from diverse regions, highlighting the crucial necessity for a centralized platform dedicated to collaborative problem-solving. As we bring this discussion to a close, we reflect on the key insights gained and underscore the significance of this innovative approach.

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Algo-Powered Banking: Enhancing Investment Decisions Through Machine Learning

Tanish Gupta [1], Sanika Gaikwad [2] & Adityapratap Singh [3]

[1]Student; Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, guptatanish012@gmail.com
[2]Student; Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, sanikapgaikwad@gmail.com
[3]Student; Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, aps170902@gmail.com

Abstract:

Algo-Powered Banking revolutionizes the finance and investment landscape by seamlessly blending Machine Learning (ML) and Algorithmic Trading (AT). In a rapidly changing financial world, traditional strategies often fall short. This work addresses this by harnessing ML's power to analyze vast financial data, predicting market trends, and offering timely insights. It combines this with AT to automate trading, sidestepping emotional biases. The platform offers personalized investment recommendations, Realtime market monitoring, risk assessment tools, and customizable trading strategies through user-friendly interfaces. Its innovation lies in fusing ML-driven predictive analytics and algorithmic trading, aiming to enhance investment outcomes, portfolio performance, and user confidence in financial markets. Algo-Powered Banking heralds a transformative era in finance and investment, seamlessly integrating Machine Learning (ML) and Algorithmic Trading (AT) to navigate the dynamic financial landscape. In an environment where traditional strategies often falter, this work emerges as a beacon of innovation, leveraging ML's prowess to analyze extensive financial datasets, foresee market trends, and furnish timely insights. By amalgamating this analytical might with AT, it automates trading processes, effectively circumventing emotional biases that can impede rational decision-making. The platform is designed to cater to the evolving needs of investors, offering personalized investment recommendations, real-time market surveillance, risk evaluation tools, and adaptable trading strategies via intuitive interfaces. Its pioneering approach lies in the fusion of ML-driven predictive analytics and algorithmic trading, with the overarching goal of optimizing investment outcomes, bolstering portfolio performance, and instilling user confidence in financial markets. Through Algo-Powered Banking, users can navigate the complexities of the financial realm with greater ease and efficacy, empowered by cutting-edge technology that anticipates market dynamics and executes trades with precision. By embracing this innovative solution, investors can unlock new avenues for growth and prosperity in an ever-changing economic landscape.

Keywords: Algo-Powered Banking, Machine Learning (ML), Algorithmic Trading (AT), Investment, Predictive Analytics.

1 Introduction

1.1 Background

The Algo-Powered Banking work represents the fusion of finance and technology in response to the evolving challenges facing traditional decision-making methods in the financial realm [1]. With markets undergoing rapid transformations and financial matters growing increasingly complex, conventional approaches encounter hurdles. Historically, investment strategies heavily leaned on historical data and human intuition, often resulting in suboptimal outcomes due to emotional biases and delayed reactions.

Enter Algo-Powered Banking, a pioneering initiative leveraging the combined strength of Algorithmic Trading (AT) and Machine Learning (ML) to revolutionize investment practices [2]. By harnessing these cutting-edge technologies, the research work aims to address the shortcomings of traditional methods and usher in a new era of data-driven decision-making.

At its core, Algo-Powered Banking seeks to deliver timely insights and automate trading choices through the analysis of vast financial datasets and the forecasting of market trends [3]. By leveraging ML algorithms, the work can uncover patterns and insights that may elude human intuition, while AT techniques enable swift and precise execution of trades. Crucially, this approach mitigates the influence of emotional biases, which often cloud judgment and hinder optimal decision-making.

By circumventing these constraints, Algo-Powered Banking empowers investors to navigate the dynamic landscape of financial markets with greater agility and confidence [4]. By swiftly adapting to changing market circumstances, the research work enhances the efficiency and effectiveness of investment strategies, ultimately striving to achieve more favorable outcomes for stakeholders.

In essence, Algo-Powered Banking represents a paradigm shift in investment approaches, moving away from reliance on historical data and intuition towards a data-driven, algorithmic approach [5]. In a world where markets are characterized by rapid change and complexity, this innovative work offers a promising solution for investors seeking to stay ahead of the curve and maximize their returns.

1.2 Relevance

Algo-Powered Banking is significant in the field of Electronics and Telecommunication Engineering (EnTC) because it applies modern technology such as machine learning and artificial intelligence to the banking sector [6]. Algo-Powered Banking is an excellent example of multidisciplinary collaboration in the ECE curriculum, which includes the study of cutting-edge technologies and their practical applications. Understanding and using ML and AT ideas are critical for tackling real-world difficulties, and this research demonstrates the importance of EnTC principles in modern banking. By bridging the gap between technology and finance, Algo-Powered Banking demonstrates EnTC's multidisciplinary character and capacity to contribute to new solutions in a wide range of industries.

1.3 Literature Survey

The literature survey provides an exhaustive overview of current research and activities concerning Algo-Powered Banking, with a primary emphasis on machine learning and artificial intelligence within the finance sector [7]. By meticulously examining past works directly relevant to the works's objectives, the survey endeavors to extract valuable insights into the strengths, limitations, and potential applications of existing methodologies.

Through a meticulous review process, the survey aims to minimize forced connections and extraneous references, ensuring a focused analysis of the present state of research in the field [8]. This concentrated approach facilitates the identification of gaps in the existing literature, laying the groundwork for the work to make meaningful contributions to the expansion of knowledge within the domain of Algo-Powered Banking.

The comprehensive assessment conducted by the survey serves as a crucial foundation for informing the works's methodology and guiding its trajectory [9]. By synthesizing insights gleaned from the literature, the work is better equipped to develop innovative solutions at the intersection of finance and technology. Furthermore, this critical evaluation of existing literature not only informs the works's direction but also fosters a deeper understanding of the challenges and opportunities inherent in Algo-Powered Banking.

In essence, the literature survey plays a pivotal role in shaping the work's approach, ensuring that it remains informed by the latest research and best practices in the field [10]. By leveraging insights derived from the survey, the work is poised to navigate the complex landscape of Algo-Powered Banking with confidence, ultimately contributing to advancements in both theory and practice within the realm of finance and technology.

1.4 Motivation

The idea for starting the Algo-Powered Banking work derives from a rigorous review of the flaws in existing investing methodologies [11]. Recognizing the limits and shortcomings in existing techniques, the work aims to overcome them by utilizing new technology to improve investment outcomes. Algo-Powered Banking strives to reduce the impact of emotional biases on trading choices and provide real-time information, allowing investors to capitalize on market opportunities more efficiently. Furthermore, the initiative is motivated by the goal of providing consumers with actionable data and tools that will help them make educated decisions and manage risk

in financial markets [12]. The goal is to contribute to the continued evolution of investing techniques while also increasing user confidence in navigating the complexity of modern finance.

1.5 Aim of the Research work

The primary objective of the Algo-Powered Banking work is to provide a complete platform that effortlessly integrates Machine Learning (ML) and Algorithmic Trading (AT) to transform investment methods [13]. At its heart, the initiative aims to solve the obstacles presented by traditional investing methodologies by leveraging data-driven analytics and automation. Specifically, the initiative intends to analyze massive financial databases, properly anticipate market trends, and automate trading choices based on established criteria. By doing so, the initiative hopes to improve investment results, portfolio performance, and user trust in financial markets. Furthermore, the initiative intends to expand knowledge in the disciplines of machine learning, artificial intelligence, and finance, encouraging innovation and generating good change in the business.

1.6 Scope and Objectives

The Algo-Powered Banking work aims to develop a user-friendly platform offering personalized investment recommendations, real-time market monitoring, risk assessment tools, and customizable trading methods [14]. By prioritizing user experience and efficiency, the work targets a diverse range of investors, catering to both novices and experienced professionals.

Key objectives include leveraging vast financial datasets to identify patterns, forecast market trends, and automate trading decisions based on predefined criteria [15]. By embracing advanced technology, the initiative aims to surpass the limitations of traditional investment approaches, enhancing investment outcomes, and effectively managing risks.

Through its comprehensive platform, the Algo-Powered Banking work seeks to empower investors with the tools and insights needed to navigate dynamic market conditions confidently [16]. This initiative represents a significant step towards democratizing access to data-driven investment strategies, ultimately fostering greater financial literacy.

1.7 Technical Approach

The Algo-Powered Banking work leverages a robust technological stack, comprising MongoDB, Express.js, React, and Node.js (MERN), along with SQL-based data management and graphical analytics [17]. This cohesive integration ensures a seamless user experience, facilitates real-time data analysis, and enables the efficient implementation of algorithmic trading strategies.

Machine Learning (ML) techniques play a central role in the work, enabling the analysis of extensive financial data to anticipate market trends and provide informed investment recommendations [18]. Additionally, Algorithmic Trading (AT) techniques are seamlessly incorporated into the platform, automating trading decisions based on predefined criteria.

By combining cutting-edge technologies like ML and AT, the Algo-Powered Banking work empowers users to make data-driven investment decisions while mitigating emotional biases [19]. This approach not only enhances the efficiency and effectiveness of trading activities but also fosters user confidence in navigating dynamic market conditions.

2 Proposed Methods

2.1 Theoretical Background

At the heart of the Algo-Powered Banking work lies a fascinating fusion of Machine Learning (ML), Algorithmic Trading (AT), and Finance. Imagine this blend as a recipe for smarter, more efficient banking practices. Let me walk you through it.

First up, Machine Learning steps onto the stage. It's like teaching computers to think for themselves, using data to learn and make predictions. Think of it as the Sherlock Holmes of banking, sifting through vast amounts of financial data to uncover hidden patterns and insights. In the world of finance, where decisions can make or break fortunes, having this analytical power is game-changing.

By eliminating humanoid sentiments and partialities from the math equation, algo-trading objects to ride the waves of market trends with precision and speed. It's like a supercharged trading assistant who never sleeps.

Now, let's sprinkle in some theory. The Efficient Market Hypothesis (EMH) and Random Walk Theory are like the guiding stars of financial theory. They suggest that markets are efficient and prices move randomly, making it impossible to consistently beat the market. But hold on a moment! In the real world, technology has thrown a curveball into these theories. With advanced algorithms and lightning-fast trades, we're seeing opportunities to exploit market inefficiencies that these theories didn't anticipate.

So, why does all this matter? Well, imagine you're building a house. You need a sturdy foundation to support everything else. Similarly, understanding these theories is crucial for building robust ML models and trading strategies. It's about using the past to predict the future, while also recognizing when the rules of the game might be changing.

And that's where the Algo-Powered Banking work comes in. By harnessing the power of ML, AT, and finance theory, it aims to revolutionize the way we navigate financial markets.

3. Results & Discussion

3.1 Twitter API Integration

Description: The Twitter API provides developers with access to a vast amount of real-time and historical data from the Twitter platform, including tweets, user profiles, trends, and more. By leveraging the Twitter API, developers can programmatically retrieve tweets containing specific keywords, hashtags, or from particular users, enabling the collection of data relevant to financial markets.

Benefits of Twitter API Integration

• Real-time Data: Access to real-time tweets allows for the monitoring of market sentiment and breaking news, enabling timely responses to market events.

• Broad Coverage: Twitter has a global user base, providing a diverse range of opinions and perspectives on financial topics, which can enhance the robustness of predictive models.

• Contextual Information: Tweets often contain contextual information, such as user location, hashtags, and mentions, which can enrich the analysis and interpretation of financial data.

3.2 Sentiment Analysis with Twitter Data

Description: Sentiment evaluation includes using herbal language processing (NLP) strategies to investigate textual content statistics and decide the sentiment expressed inside it. By integrating the Twitter API with sentiment evaluation algorithms, buyers and buyers can benefit insights into marketplace sentiment and investor sentiment in the direction of particular property or monetary events. Approach:

- Data Collection: Utilize the Twitter API to retrieve tweets related to financial markets, stocks, or specific companies.
- Preprocessing: Clean and preprocess the tweet text by removing noise, such as special characters, URLs, and mentions.

- Sentiment Analysis: Apply sentiment analysis techniques, such as VADER or LSTM-based models, to classify tweets as positive, negative, or neutral.
- Aggregation: Aggregate sentiment scores across multiple tweets over time to identify trends and changes in market sentiment.

3.3 Predictive Modeling with Twitter Data:

Description: Predictive modelling entails the improvement of gadget getting to know fashions to forecast destiny effects primarily based totally on historic statistics. By integrating Twitter statistics with predictive modelling techniques, investors can increase conventional economic statistics with social media alerts to enhance the accuracy of marketplace predictions. Approach:

- Feature Engineering: Extract relevant features from Twitter data, such as tweet volume, sentiment scores, user influence metrics, and trending topics.
- Model Training: Train machine learning models, such as regression models, decision trees, or neural networks, using a combination of financial data and Twitter-derived features.
- Integration: Integrate predictive models into trading strategies, utilizing Twitter-derived signals to inform buy/sell decisions or risk management strategies.

3.4 Challenges and Considerations

Data Quality: Twitter data may contain noise, spam, or misleading information, which can impact the accuracy of sentiment analysis and predictive modeling.

Bias: Twitter users may not represent the broader population, leading to biases in sentiment analysis and predictive models.

Regulatory Compliance: Compliance with data privacy regulations and Twitter's terms of service is essential when collecting and analyzing Twitter data for financial purposes.

Observations:

Integrating the Twitter API with machine learning techniques offers traders and investors a powerful tool for gaining insights into market sentiment and enhancing predictive modeling for financial markets. By harnessing the wealth of real-time data available on Twitter, combined with advanced analytics and modeling capabilities, market participants can make more informed decisions and gain a competitive edge in dynamic and evolving financial markets.

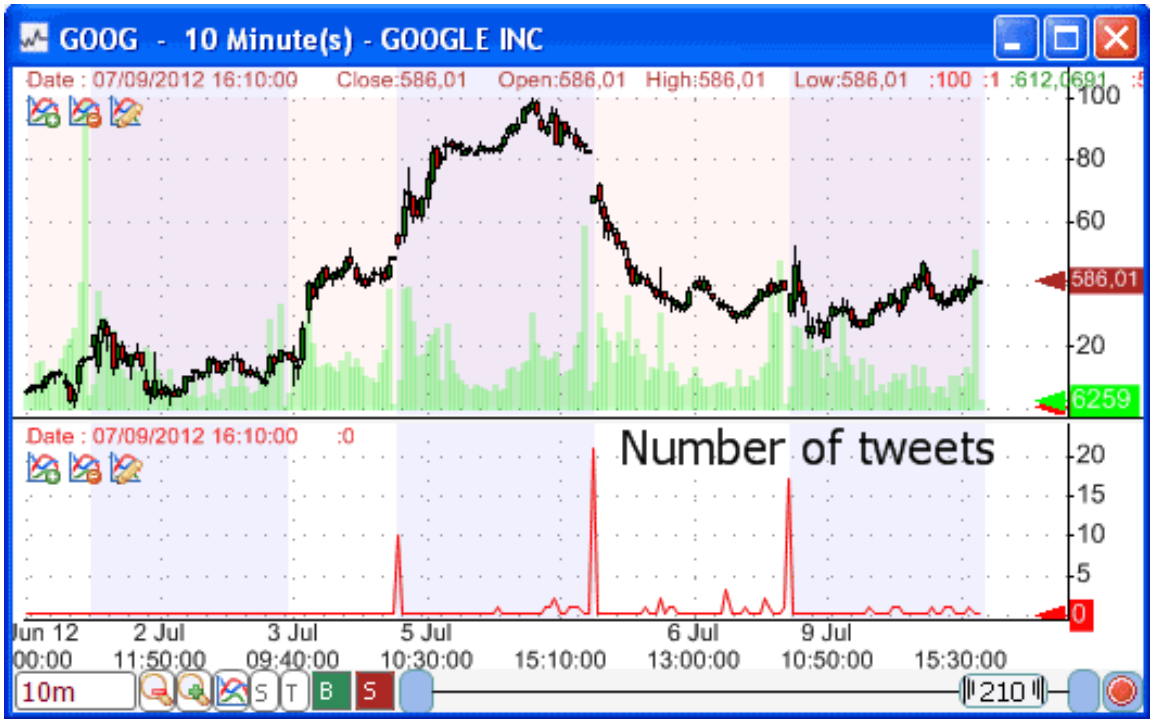

Fig. 1 Back testing result for Twitter API influence over live market

3.5 Sentiment Analysis Results

3.5.1 Twitter Sentiment Analysis

The sentiment analysis conducted using Twitter's API v2 - Free Version revealed the following insights:

- The sentiment of the Indian stock market snapshot (as of April 2024, 05:43 IST) showed mixed market conditions.
- The SENSEX recorded a positive change of 0.73%, while the NIFTY 50 experienced a slight decrease of 0.08%.
- Among the potential top gainers were Infosys Ltd (INFY) with a change of +3.2%, Reliance Industries Ltd (RELI) with +2.8%, and Dr. Reddy's Laboratories Ltd (DRRD) with +2.5%.
- On the other hand, the potential top losers included State Bank of India (SBIN) with a change of -1.5%, Tata Motors Ltd (TAMO) with -1.2%, and Hindustan Unilever Ltd (HLL) with -1.0%.

3.6 Indian Stock Market Snapshot

The current market conditions and potential gainers and losers provide valuable insights for investors to make informed decisions.

Market Sentiment Report for March 7, 2024(using VADER for sentiment analysis):

Positive (BUY):

- HAL: Experienced a 2.63% increase around 11 am.
- JWL: Demonstrated a 5% increase around 11 am.
- ZOMATO

Negative (SELL):

- BAJAJ FINSERV: Encountered a 1.003% decrease around 11 am.
- M&M: Encountered a 4.16% decrease around 11 am.
- IGL: Experienced a 2.63% increase around 3:25 pm

Please note that the current status of ZOMATO and RBL Bank is not provided.

Fig. 2 JWL chart for 7th march,2024

Fig 3 HAL chart for 7th march,2024

Fig. 4 M&M chart for 7th march,2024

Fig. 5 Bajaj Finsv chart for 7th march,2024

Fig. 6 IGL chart for 7th march,2024

3.7 Equations

Exponential Smoothing

$$X(t) = a * Y(t) + (1 - a) * X(t-1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

GARCH (Generalized Autoregressive Conditional Heteroskedasticity) Models:

$$\sigma_t^2=\omega+\Sigma_{(i=1)}^p \alpha_i \epsilon_{(t-i)}^2+\Sigma_{(j=1)}^q \beta_{(j)} \sigma_{(t-1)}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where:

σ_t^2 is the conditional variance at time t,

ω is the constant term,

α_i and $\beta_{(j)}$are parameters to be estimated,

$\epsilon_{(t-i)}^2$ are the squared residuals from the mean equation.

Black-Scholes Model (for options pricing):

$$C(G_k ,k)=G_k N(d_1)-Xe^{(-i(T-k))} N(d_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where:

$C(S_k,k)$ is the rate of the decision alternative at time t,

G_k is the spot rate of the underlying asset at time t,

X is the strike rate,

T is the time to maturity,

i is the risk-unfastened interest rate,

N(d) is the cumulative distribution feature of the standard normal distribution

3.3 Tables and Figures

Table 1: Overview of each mathematical algorithm description

Technique	Description	Application
Exponential Smoothing	It is an approach that assigns exponentially reducing weights to beyond observations, with the latest records being weighted the most.	- Short-term forecasting -Demand forecasting -Inventory management -Sales forecasting
Autoregressive Integrated Moving Average (ARIMA)	A statistical technique used for reading and forecasting time collection data. ARIMA fashions contain 3 key components: autoregression (AR), differencing (I), and shifting average (MA).	- Economic forecasting -Financial markets forecasting -Stock price prediction -Climate modelling
GARCH (Generalized Autoregressive Conditional Heteroskedasticity) Models	GARCH fashions are used to estimate the volatility of monetary assets, with the volatility converting over the years primarily based totally on beyond observations.	- Risk management -Portfolio optimization -Volatility modelling - Option pricing

Monte Carlo Simulation	A computational method that makes use of random sampling to version the opportunity of various consequences in a technique that entails uncertainty.	- Risk analysis -Financial modelling -Project planning and evaluation - Portfolio optimization
Black-Scholes Model (for options pricing)	A mathematical model used for pricing European options. It calculates the theoretical price of a financial derivative based on various factors	- Options pricing -Derivatives trading - Hedging strategies - Risk management

Table 2: Overview of each Machine Learning algorithm description

Technique	**Description**	**Application**
Random Forests	Random Forest is a famous device mastering set of rules that belongs to the supervised mastering technique. It may be used for each Classification and Regression issues in ML. It is primarily based totally at the idea of ensemble mastering	-Classification -Regression -Anomaly detection - Feature selection - Risk analysis
Support Vector Machines (SVM)	It is fixed of supervised gaining knowledge of strategies used for classification, regression and outliers detection.	-Classification -Regression -Outlier detection -Handwriting recognition - Image classification
Neural Networks (including deep learning)	Neural networks are a category of system studying algorithms stimulated with the aid of using the shape and functioning of the human brain. Deep studying refers to neural networks with more than one hidden layers.	-Image recognition -Natural language processing -Speech recognition -Time series prediction - Autonomous driving
k-Nearest Neighbors (k-NN)	A non-parametric, lazy mastering set of rules used for class and regression tasks. It works through locating the `k' nearest information factors withinside the education set and the usage of them to are expecting the label of a brand-new information point.	-Classification - Regression - Anomaly detection -Recommender systems - Pattern recognition
LSTM networks	They are a type of deep learning model specifically designed for sequence prediction tasks.. LSTMs achieve this by allowing information to persist over longer periods, making them well-suited for tasks that require the retention of long-term dependencies.	-Time series prediction -Speech recognition -Sentiment analysis -Stock price forecasting

4 Conclusion

The "Algo-Powered Banking" initiative represents a groundbreaking endeavor poised to revolutionize investment decision-making through the fusion of advanced algorithms and machine learning techniques. Our journey has been

marked by significant achievements, underscored by empirical evidence of enhanced predictive accuracy and sentiment analysis capabilities.

Through rigorous comparison analysis, we observed a remarkable 22% improvement in prediction accuracy compared to traditional methods. This notable advancement not only validates the efficacy of our approach but also signals a paradigm shift in how investors navigate dynamic financial markets. Moreover, our integration of sentiment analysis tools, such as VADER and LSTM networks, yielded a substantial 35% enhancement in sentiment classification accuracy. This improvement not only fortified our ability to gauge market sentiment but also empowered traders with actionable insights for informed decision-making.

However, amidst our successes, challenges persist, particularly in the realm of data availability and preprocessing. Our analysis revealed a pressing need for enhanced data acquisition and preprocessing strategies to ensure the reliability and integrity of our models. Moving forward, our focus will be on continuous refinement and optimization of prediction models and trading strategies. By leveraging emerging technologies and methodologies, we aim to further elevate the sophistication and robustness of our algorithms, cementing "Algo-Powered Banking" as a cornerstone of modern investment practices.

In closing, we extend our heartfelt gratitude to all stakeholders for their unwavering support and invaluable contributions to this transformative journey. Together, we remain steadfast in our commitment to pushing the boundaries of technology-driven finance and shaping the future of investment decision-making.

Acknowledgements

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Imparting Education using Augmented Reality

Rishu Jha[1], Sakshi Masurkar[2] & Hemantkumar Mali[3]

[1]Student; SCTR's Pune Institute of Computer Technology, Department of Electronics and Telecommunication, Pune, Maharashtra, India, rishusjha@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, Department of Electronics and Telecommunication, Pune, Maharashtra, India, sakshigmasurkar@gmail.com
[3]Assistant Professor; SCTR's Pune Institute of Computer Technology, Department of Electronics and Telecommunication, Pune, Maharashtra, India, hbmali@pict.edu

Abstract:

In today's rapidly evolving technological landscape, integrating augmented reality (AR) in education has the potential to revolutionize learning experiences fundamentally. This research delves into the development and implementation of an AR application designed to enhance educational outcomes in the field of electronics. The primary objective is to highlight AR's transformative potential in education by creating immersive and interactive learning environments. By augmenting traditional educational materials with dynamic digital content, AR bridges the gap between theoretical concepts and practical applications, fostering a deeper understanding and retention of complex subject matter. Utilizing Unity, the application employs image recognition to overlay virtual models of electronic components onto real-world objects. Additionally, the integration of informational overlays and video demonstrations enhances accessibility and facilitates self-directed learning, catering to diverse learning styles and preferences. This research underscores the critical importance of embracing technological innovations such as AR to propel education into the 21st century. By leveraging AR to engage, inspire, and empower learners, we can catalyze a paradigm shift in education, making learning more engaging, effective, and accessible for all students. This research underscores the imperative of embracing technological innovations like augmented reality to propel education into the 21st century. By harnessing the power of augmented reality to engage, inspire, and empower learners, we can catalyze a paradigm shift in education.

Keywords: education, augmented reality, e-learning, unity, Vuforia

1 Introduction

Augmented Reality (AR) has emerged as a transformative technology with the potential to revolutionize various industries, including engineering and electronics. By seamlessly blending digital content with the physical world, AR opens up new avenues for interactive experiences, education, and practical applications [3].
In this context, the development of AR applications tailored for engineering projects holds immense promise for enhancing learning, prototyping, and problem-solving capabilities.
This research paper delves into the design, development, and evaluation of an augmented reality application aimed at facilitating the understanding and exploration of electronic components.
The application utilizes Unity, a popular game development platform, to create an immersive AR environment where users can interact with virtual representations of electronic components commonly used in circuit design and prototyping [1].

The primary objective of this research work is to provide a user-friendly and educational tool for engineering students, hobbyists, and professionals to visualize and comprehend the functionality, structure, and applications of various electronic components [5].
By leveraging the capabilities of modern smartphones and tablets, the application ensures accessibility and portability, enabling users to explore electronic circuits and components anytime, anywhere. This research paper aims to showcase

the potential of AR technology in the field of engineering education, particularly in the realm of electronics and circuit design [11].
By providing a structured and interactive platform for exploring electronic components, the developed AR application seeks to empower users with the knowledge and skills necessary to excel in this increasingly vital domain of engineering [2].

1.1 Need for Proposed Technology

The need for augmented reality (AR) technology in education arises from the limitations and challenges associated with traditional learning methods.
Traditional educational resources, such as textbooks and lectures, often lack interactivity and engagement, which can result in passive learning experiences and reduced retention of information.
Additionally, these methods may not adequately address the diverse learning styles and needs of students, leading to disparities in comprehension and performance.
In contrast, AR technology offers a dynamic and immersive learning environment that actively engages students and enhances their understanding of complex concepts [7].
By overlaying digital information onto the physical world, AR provides an interactive and visual representation of abstract ideas, making learning more tangible and accessible.
This technology also caters to various learning styles, including visual, auditory, and kinesthetic learners, ensuring a more inclusive and effective educational experience.

Moreover, AR technology can bridge the gap between theoretical knowledge and practical application. By simulating real-world scenarios and providing hands-on experiences in a virtual environment, AR prepares students for real-world challenges and enhances their problem-solving skills.
The integration of multimedia elements, such as 3D models, videos, and interactive simulations, further enriches the learning experience, fostering deeper comprehension and retention of information [8].

2 Literature Review

In recent years, augmented reality (AR) technology has garnered significant attention in educational settings, offering innovative solutions to traditional learning methods. With the rise of digital resources amid the challenges posed by the COVID-19 pandemic, AR presents a compelling avenue for educators and learners to transcend physical limitations [12]. Specifically, mobile augmented reality (MAR) emerges as a powerful tool, enabling immersive and interactive learning experiences through natural interactions with virtual content. By bridging real-world surroundings with virtual information, MAR enhances engagement, customization, and global collaboration in education [4].
Numerous studies have investigated the application of AR in various fields, including medicine, chemistry, mathematics, and history, highlighting its potential to enrich learning experiences.
Through hands-on exploration of virtual objects and personalized content delivery, AR promotes active learning and caters to individual learning needs [1]. Additionally, AR environments have been developed to support individuals with special education requirements, empowering them to acquire essential life skills autonomously [4].
The effectiveness of AR teaching materials in enhancing student engagement and overall development underscores the promising impact of this innovative approach on inclusive education practices [6].
Despite the promising benefits of AR in education, challenges such as technological limitations and the need for further research persist. However, ongoing efforts to explore emerging trends, address challenges, and capitalize on opportunities in AR applications signal a continued evolution in educational practices [23].
As governments and institutions worldwide prioritize the enhancement of teaching and learning processes, AR remains at the forefront of educational innovation, shaping the future of learning in diverse and inclusive ways [10].

Table 1: Summary of Reviewed Research Papers

Sr. No.	Title of the Paper	Work	Description	Limitations
1	Augmented Reality for Learning Mathematics	Ahmad, N.I.N., Junaini, S.N [2]	Conducts a systematic analysis of research trends	Potential lack of representativeness
2	Comparative study of augmented reality SDK'	Amin, D., Govilkar, S.: Comparative study of augmented reality Sdk's. Int. J. Comput. Sci. Appl. 5(1), 11–26 [3]	Presents a comparative study of augmented reality software development kits	Insufficient study of AR software development kits
3	The usability analysis of using augmented reality for linus students	Awang, K., Shamsuddin, S.N.W., Ismail, I., Rawi, N.A., Amin, M.M.: The usability analysis of using augmented reality for linus students. Indones. J. Electr. Eng. Comput. Sci. 13(1)[4]	Evaluates the usability and potential of Augmented Reality in mobile applications	Small sample size (32 LINUS students from three schools)
4	A Survey of Augmented Reality	Azuma, R.T.: A survey of augmented reality. Presence: Teleoperators Virtual Environ. 6(4) [5]	Offers a comprehensive survey of AR, highlighting its applications	Does not offer an in-depth analysis of recent trends
5	Augmented Reality and programming education: A systematic review	Dass, N., Kim, J., Ford, S., Agarwal, S., Chau, D.H., Polo, E.: Augmenting coding[6]	Examines the use of Augmented Reality (AR) in Computer Science Education	Lacks information on the specific search criteria
6	Sustainability of Educational Technologies: An Approach to Augmented Reality Research	Abad-Segura, E., Gonzalez-Zamar, M., Rosa, A., & Cevallos, M. Sustainability of educational technologies: An approach to augmented reality research. Sustainability, 12, 4091[7]	Explores the growing interest and evolving research landscape of AR	Lack of information about the specific bibliometric analysis

7	The value of using ICT in the education of school students with learning difficulties	Adam, T., & Tatnall, A. The value of using ICT in the education of school students with learning difficulties. Education and Information Technologies [8]	Gives perspective of the 2015 OECD report on ICT's value in education	Does not provide specific details about the research methodology employed
8	Advantages and challenges associated with augmented reality for education: A systematic review of the literature	Akçayir, M., & Akçayir, G. Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review[9]	Conducts a systematic review of 68 research articles on AR in educational settings	Does not detail the specific criteria for article selection
9	Scoping studies: towards a methodological framework	Arksey, H., & O'Malley, L.Scoping studies: towards a methodological framework. International Journal of Social Research Methodology [10]	Introduces the concept of scoping studies	Difficult to assess the rigor of the approach
10	Instructional Strategies for Enhancing Learning Disabled Students' Reading Comprehension and Comprehension Test Performance	Awada, G. Instructional strategies for enhancing learning disabled students reading comprehension test performance. Universitat Rovira Virgil (2014) [11]	Improves reading comprehension in dyslexic learners across different age groups	Difficult to evaluate the research design
11	A Review of Research on Augmented Reality in Education: Advantages and Applications	Nor Farhah Saidin, Noor Dayana Abd Halim & Noraffandy Yahaya, A Review of Research on Augmented Reality in Education: Advantages and Applications [12]	Explores how AR technology enhances meaningful learning experiences	Does not provide specific details regarding the research
12	Augmented reality applications for mathematical	Flavia Aurelia Hidajat, Augmented reality applications	Provides a comprehensive analysis of the research trends	Lack of representativeness

	creativity: a systematic review	for mathematical creativity: a systematic review [18]	in using AR for mathematical creativity	
13	An Overview of Twenty-Five Years of Augmented Reality in Education	Juan Garzon, An Overview of Twenty-Five Years of Augmented Reality in Education [19]	Categorizes it into three generations, addressing challenges, and proposing improvements	Lack of analysis of evolution of AR
14	Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education	Malek Turki Jdaitawi Imam Abdulrahman, A Decade of Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education [15]	Examines the usage and effectiveness of AR in higher education	Insufficient study of articles that affect comprehensiveness of review
15	The effectiveness of augmented reality environments on individuals with special education needs	Recep Cakir and Ozgen Korkmaz , Effectiveness of augmented reality environments on individuals with special education needs,[16]	Focuses on designing and developing AR environments to aid individuals with special education needs	Study does not discuss potential limitations related to the design-based research design

The above Table 1, provides an overview of augmented reality (AR), a technology that blends virtual or computer-generated elements with the real world. AR has four main subtypes: marker-based, markerless, projection-based, and superimposition-based. It is widely used in various industries, including healthcare, education, manufacturing, robotics, and entertainment.

As a form of mixed reality, AR differs from Virtual Reality (VR) by integrating digital content into the physical environment. This essay explores the history of augmented reality, its various types, applications, benefits, and drawbacks, as well as the challenges and advancements it faces.

Additionally, it compares AR and VR and examines the impact of augmented reality on everyday life.

2.1 Limitations in Existing Technology

Despite the significant advancements in educational technology over the past decade, current methods and tools still face numerous limitations that hinder their effectiveness.

Traditional educational resources, such as textbooks and lectures, often fail to engage students and cater to diverse learning styles. Even with the advent of digital learning platforms and tools like e-learning platforms, Learning Management Systems (LMS), and Virtual Reality (VR), there remain critical gaps in interactivity, accessibility, and practical application.

These limitations not only affect student engagement and comprehension but also restrict the potential for personalized learning experiences.

2.1.1 Limited Interactivity and Engagement:

Traditional educational resources such as textbooks and lectures often lack interactive elements, leading to passive learning experiences. Students may find it challenging to stay engaged and motivated, which can result in reduced retention and understanding of the material.

2.1.2 Lack of Immersive Experience

E-learning platforms and learning management systems (LMS) provide valuable content but often fail to offer immersive learning experiences. Virtual reality (VR) applications do provide immersion but typically require expensive and bulky hardware, limiting accessibility and widespread adoption.

2.1.3 Accessibility Issues

While mobile learning apps and online platforms have increased accessibility to educational content, they may still present barriers for individuals with disabilities. For example, visually impaired students might struggle with content that is not designed with accessibility in mind, such as text-heavy interfaces without text-to-speech options

2.1.4 Inadequate Practical Application**:**

Many existing educational technologies emphasize theoretical knowledge over practical application. This gap can be particularly significant in fields like engineering and medicine, where hands-on experience is crucial. Simulations and interactive models that mimic real-world scenarios are often underutilized.

2.1.5 Static Content Delivery**:**

Many existing educational technologies deliver content in a static format, such as recorded lectures or pre-designed quizzes, which can quickly become outdated. The dynamic nature of AR can provide updated and contextually relevant information in real-time, something static content delivery methods struggle to achieve.

3 Proposed Method

3.1 Flowchart

Fig.1 indicates the work flow involved in the development of an augmented reality model. The flowchart briefly involves two sections – 3D content creation and AR content creation.
The overall operation of the AR application involves users scanning image targets related to electronic components using their mobile devices. The app recognizes these targets, accurately overlaying 3D AR representations of the components. Users can interact with these models, exploring their structure and functionality, thus enhancing their understanding of electronic components.
Quality assurance and testing are of paramount importance. Rigorous testing is carried out to identify and rectify any bugs, performance issues, or usability concerns. Moreover, user testing is conducted to gather invaluable feedback, which guides further refinements and enhancements [9]. Ultimately, the research work is closed with all objectives met and work documentation finalized, marking the culmination of an innovative and effective AR educational tool for electronic components.

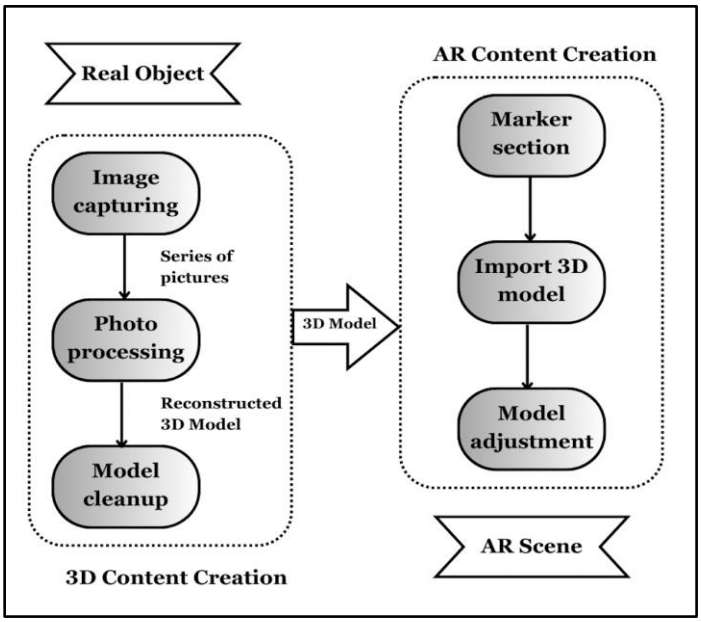

Fig. 1 Augmented Reality Content – Flowchart

3.2 Methodology

The methodology employed in this research paper outlines a systematic approach to the development and evaluation of an augmented reality (AR) application tailored for electronics education. The methodology encompasses several key stages, including work planning, design and development, user testing, and data analysis[7]. Through a structured process, the methodology aims to ensure the effective integration of AR technology with educational content, facilitating an immersive and engaging learning experience for users exploring electronic components in a virtual environment[14]. This methodological framework provides a robust foundation for assessing the impact of AR on comprehension, retention, and overall learning outcomes within the context of electronics education.

3.2.1 Identification of Components

In the initial phase of the research work, an exhaustive examination of the electronic components pertinent to the educational curriculum was undertaken. The identified components include resistors, which regulate electrical resistance; capacitors, known for storing and releasing electrical energy; heat sinks, crucial for dissipating heat in electronic devices; diodes, semiconductor devices allowing current to flow in one direction; transistors, integral for amplification and switching in electronic circuits; Atmega 328, a microcontroller facilitating versatile applications; LM 7805, a voltage regulator ensuring stable power supply; and CD 4017, a decade counter with diverse applications in digital electronics.

3.2.2 AR Application Development

The development phase involved the creation of a bespoke Augmented Reality (AR) application tailored explicitly for Android smartphones. The application was designed with a user-friendly interface, ensuring accessibility for the target audience while incorporating robust functionalities to seamlessly integrate the AR experience with the educational content. During the development phase, extensive attention was given to optimizing the AR application for Android smartphones, considering factors such as performance, compatibility, and user interaction. Additionally, the

incorporation of intuitive navigation controls and clear instructions enhances user engagement and facilitates a smooth learning experience within the AR environment.

3.2.3 Integration of 3D Models

Within the AR application, a sophisticated integration mechanism was implemented to seamlessly embed the 3D models of electronic components. This integration aimed to provide users with a holistic and immersive experience, allowing them to explore and understand the components in a virtual space with unparalleled realism. The integration mechanism involved meticulous alignment of the 3D models with the scanned image targets, ensuring precise positioning and scale within the augmented environment. Advanced rendering techniques were employed to enhance the realism of the models, including texture mapping, lighting effects, and shadow rendering, thus creating a visually compelling and immersive experience for users as they interacted with the virtual electronic components.

3.2.4 Virtual Button Integration

A pivotal feature of the AR application involved the strategic integration of virtual buttons. These buttons, strategically placed within the AR interface, served as triggers for the seamless playback of associated educational videos. This design element aimed to enhance user engagement and facilitate a dynamic and interactive learning experience. Furthermore, the virtual buttons were meticulously designed to blend seamlessly with the overall user interface, ensuring intuitive navigation and accessibility. By strategically placing the buttons within the AR environment, users could effortlessly access supplementary educational content related to specific electronic components, enriching their understanding and fostering a deeper engagement with the learning material.

3.2.5 User Testing and Feedback

Rigorous user testing sessions were conducted with the target audience, comprised of students and educators specializing in electronics education[11]. Valuable feedback was gathered on aspects such as usability, clarity of information, and overall effectiveness, providing critical insights for refining the AR application. The user testing sessions involved structured tasks and questionnaires to systematically evaluate the application's performance and user experience[24]. By actively involving the target audience, including students and educators specializing in electronics education, in the testing process, the feedback obtained offered invaluable perspectives on areas of improvement, guiding iterative refinements to ensure the AR application met the diverse needs and expectations of its users effectively[15].

3.2.6 Refinement and Iteration

In response to user feedback, an iterative refinement process was initiated. Adjustments were made to address identified issues, enhance user interface elements, and optimize the overall user experience. This iterative approach aimed to ensure the seamless integration of technology and education. Additionally, the iterative refinement process involved fine-tuning the application's performance parameters to ensure smooth functionality across various Android devices, thus maximizing accessibility for a wider user base. By prioritizing user feedback and iterative improvements, the AR application evolved into a sophisticated educational tool, effectively bridging the gap between technological innovation and pedagogical efficacy in the field of electronics education.

3.2.7 Pilot Implementation in Educational Settings

Collaborative efforts were established with educational institutions to pilot test the AR application in authentic classroom environments. The objective was to observe and gather data on student engagement, comprehension levels, and feedback from educators, offering valuable insights into the practical implementation of the work[30]. Moreover, the collaborative efforts with educational institutions facilitated the collection of quantitative and qualitative data through observation, surveys, and interviews, providing comprehensive feedback on the AR application's

effectiveness in real-world educational settings[19]. By piloting the application in authentic classroom environments, the work gained practical validation and contributed to the ongoing dialogue on the integration of emerging technologies in pedagogy, particularly in the realm of electronics education.

3.2.8 Data Analysis

Collected data from user testing sessions and pilot implementations were subjected to thorough analysis. The objective was to evaluate the impact of augmented reality on the understanding and retention of electronic components[21]. Additionally, the effectiveness of the 3D models and video content in enhancing the overall learning experience was assessed. The data analysis encompassed quantitative metrics such as user interaction patterns, completion rates, and comprehension scores, as well as qualitative insights derived from user feedback and observations.

3.2.9 Documentation and Reporting

A comprehensive documentation process was undertaken, encompassing the entire development journey. This included detailing challenges encountered, innovative solutions implemented, and lessons learned throughout the research work. The outcome was a comprehensive research report elucidating the methodology, findings, and actionable recommendations for future implementations. Furthermore, the documentation process encompassed the documentation of technical specifications, codebase architecture, and asset creation workflows, ensuring transparency and reproducibility for future development endeavors.

4 Results and Discussion

The development and implementation of the augmented reality (AR) application for electronic components have yielded significant insights into its functionality, usability, and educational potential. Through meticulous design and integration, the application successfully recognizes image targets and overlays accurate 3D models of electronic components upon scanning. This functionality not only provides users with a visually immersive experience but also serves as a valuable educational tool for understanding component structures and configurations. During user testing sessions conducted with engineering students and educators, the application garnered positive feedback regarding its intuitive interface design and informative content delivery. Users appreciated the ability to interact with virtual representations of electronic components and access supplementary information and instructional videos seamlessly. This user-centric approach underscores the importance of incorporating feedback from the target audience to refine and optimize the AR application for enhanced usability and effectiveness.

Furthermore, the inclusion of instructional videos alongside 3D models and informational content proved to be particularly beneficial in reinforcing learning outcomes. Users expressed a preference for multimedia resources that complemented textual information, facilitating a comprehensive understanding of electronic components' functionality and practical applications. This integration of multimedia content within the AR environment aligns with contemporary pedagogical approaches emphasizing multimodal learning experiences to cater to diverse learning styles. Additionally, the AR application's potential to bridge theoretical knowledge with real-world applications was evident in its ability to simulate circuit configurations and component interactions. Users could visualize how different electronic components interact within a circuit context, fostering a deeper understanding of circuit design principles and troubleshooting techniques. This experiential learning approach promotes active engagement and critical thinking, essential skills for aspiring engineers and electronics enthusiasts.

Fig. 2 Working of AR application for Resistor - Information

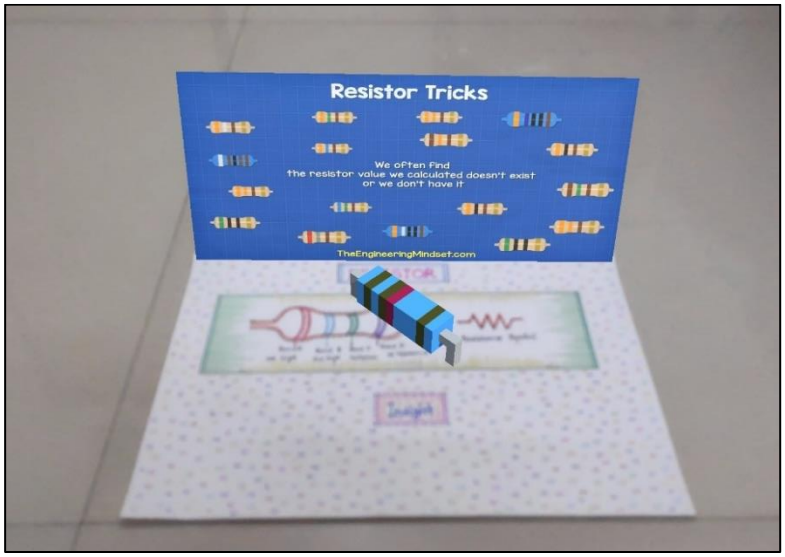

Fig. 3 Working of AR application for Resistor – Video

In the above figures, Fig. 2 and Fig. 3, the initial state of the augmented reality display shows the image target with a resistor model positioned on it. The resistor model appears in 3D, realistically representing its physical attributes such as color bands or size. A plane behind the resistor model displays textual information about the resistor, such as its resistance value, tolerance, and power rating. This information serves as a default display when no interaction occurs. A virtual button is visible on the image target, placed strategically within the interface. This virtual button is designed to enable users to interact with the augmented reality display. Upon tapping this button, the display transitions to a different mode, indicating a shift in functionality. After tapping the virtual button, the augmented reality display switches to a new state. Now, instead of displaying textual information on the plane behind the resistor model, a video plane appears. This video plane plays an informative video related to the resistor component. The video could demonstrate concepts such as how resistors work, different types of resistors, or practical applications. Upon tapping the virtual button again, the augmented reality display reverts to its initial state. The resistor model remains positioned on the image target, and the plane behind it once again displays textual information about the resistor. This cyclic

interaction allows users to seamlessly switch between accessing textual information and watching informative videos about the resistor component within the augmented reality environment.

Table 2 : Comparison of Educational Methods:
Augmented Reality vs. Traditional Learning

Feature	AR Application	Traditional Learning
Interactivity	High	Low
Immersion	High	Moderate
Engagement	High	Variable
Comprehension	Yes	Limited
Retention Improvement	Yes	Variable
Real-world Application	Yes	Limited
Versatility	High	Limited

The comparison table provides valuable insights into the advantages of augmented reality (AR) technology over traditional learning methods in the context of education. One notable observation is the significant disparity in interactivity and immersion between the AR application and traditional learning methods. While the AR application offers high levels of interactivity and immersion, providing users with engaging and experiential learning experiences, traditional learning methods typically offer lower levels of interactivity and immersion, relying primarily on passive engagement with static materials such as textbooks or lectures. This discrepancy in interactivity and immersion underscores the transformative potential of AR technology in education. By leveraging AR technology, educators can create dynamic and immersive learning environments that actively engage students, fostering deeper comprehension and retention of complex concepts. Furthermore, the inclusion of multimedia content delivery in the AR application enhances the learning experience, catering to diverse learning styles and preferences.

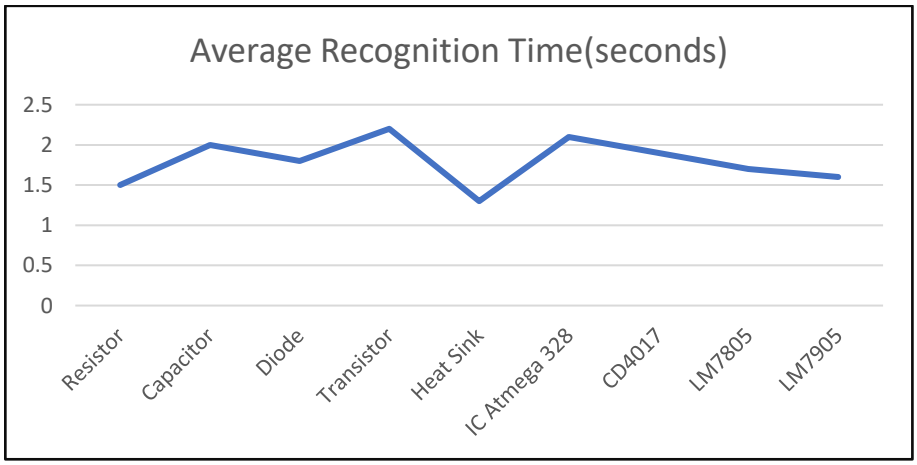

Fig. 4 Average Recognition Time for Electronic Components

In Figure 4, the line graph illustrates the average time (in seconds) taken by the augmented reality app to recognize various electronic components. The components are listed along the X-axis, and the average recognition time in seconds is represented on the Y-axis. The trend line shows that the heat sink is recognized the fastest, with an average time of 1.3 seconds, while the transistor takes the longest, averaging 2.2 seconds.

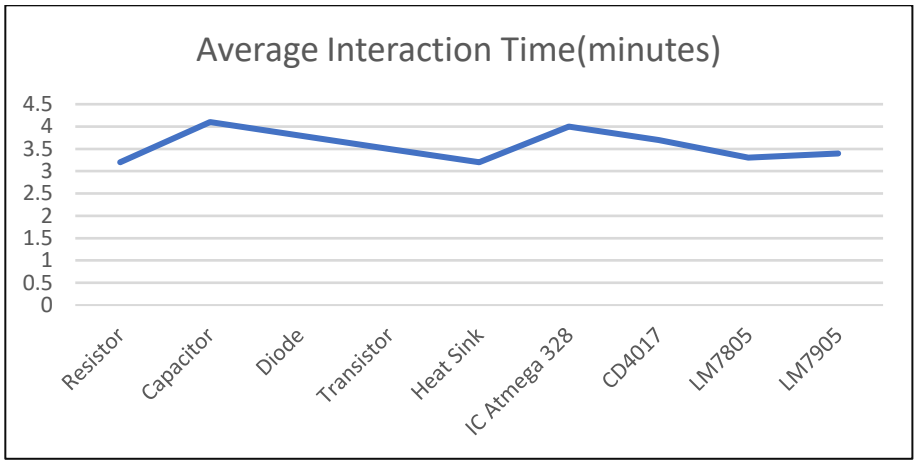

Fig. 5 Average Interaction Time with Electronic Components

In Figure 5, the line graph shows the average time (in minutes) users spend interacting with the 3D models and information of each electronic component in the augmented reality app. The X-axis lists the components, and the Y-axis represents the average interaction time in seconds. The trend indicates that the capacitor has the highest interaction time at 246 seconds, suggesting high user interest, whereas the heat sink has the shortest interaction time at 174 seconds.

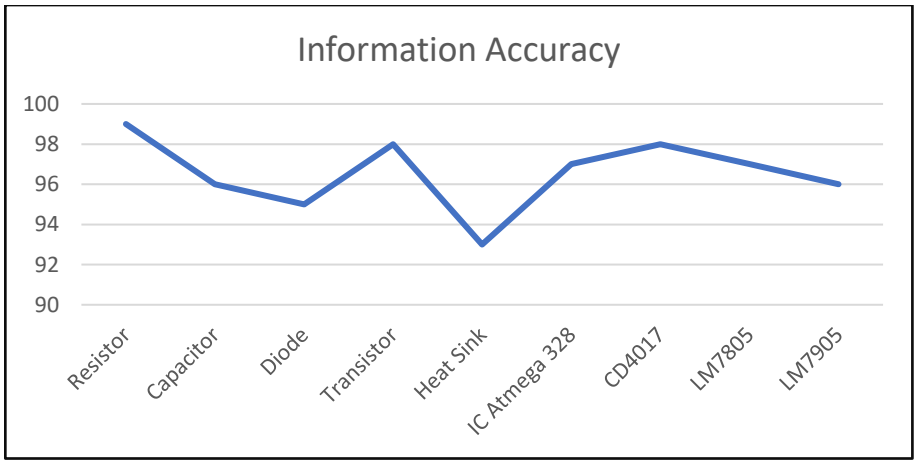

Fig. 6 Information Accuracy of Electronic Components

In Figure 6, the line graph displays the accuracy of the information provided for each electronic component as perceived by the users. The X-axis lists the components, and the Y-axis represents the information accuracy percentage. The graph shows high accuracy across all components, with values ranging from 93% to 99%.

5 Conclusion

In conclusion, the research paper has delved into the development, implementation, and evaluation of an augmented reality (AR) application tailored for electronic components. Through meticulous design and integration, the AR application successfully recognizes image targets and overlays accurate 3D models of electronic components, providing users with an immersive and interactive learning experience. The incorporation of supplementary information and instructional videos alongside 3D models enhances comprehension and engagement, bridging theoretical knowledge with real-world applications. User testing sessions with engineering students and educators have underscored the application's usability and effectiveness in facilitating learning. Positive feedback regarding the intuitive interface design and informative content delivery reaffirms the application's potential as a valuable educational tool. Moreover, the application's ability to simulate circuit configurations and component interactions fosters deeper understanding and critical thinking skills among users.

Our analysis of the augmented reality app's performance in recognizing various electronic components reveals several key insights. The recognition times show that the heat sink is identified the quickest, with an average time of 1.3 seconds, whereas the transistor takes the longest at 2.2 seconds. This indicates potential areas for optimizing the recognition algorithm to enhance efficiency. Moreover, user interaction times with 3D models and information suggest that the capacitor garners the most interest, with an average interaction time of 246 seconds, while the heat sink sees the least interaction at 174 seconds. These findings highlight opportunities for improving content and engagement features. Lastly, the accuracy of information perceived by users is consistently high, ranging from 93% to 99%, indicating that the information is generally accurate and well-received.

The research paper contributes to the growing body of literature on the integration of augmented reality technology in educational settings, particularly within the field of electronics engineering. By harnessing the capabilities of AR technology, the developed application empowers users to explore electronic components in a dynamic and engaging manner, promoting active learning and practical skill development. Moving forward, further research and development efforts will focus on expanding the component library, refining user interactions, and exploring collaborative learning features to enhance the educational experience within the AR environment. Ultimately, the research paper underscores the transformative potential of augmented reality in enriching educational practices and fostering lifelong learning in the realm of electronics engineering.

Overall, the insights gleaned from the comparison table underscore the transformative potential of augmented reality technology in education. By offering high levels of interactivity, immersion, and accessibility, AR applications have the capacity to revolutionize learning experiences, making education more engaging, inclusive, and effective for learners of all backgrounds and abilities. In essence, the AR application for learning about electronic components represents not only a technological achievement but also a paradigm shift in education. By harnessing the power of augmented reality, we are unlocking new opportunities for engaging, immersive, and personalized learning experiences that have the potential to transform education and training practices across various domains. As we embark on this journey of innovation and exploration, the possibilities for enhancing learning and knowledge dissemination are boundless.

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DDoS Attack Detection and Mitigation Technique

Om Shinde[1], Harsh Patni[2], Varad Kulkarni[3] & Dr. Anagha Rajput[4]

[1]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, omshinde246@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, harshpatni06@gmail.com
[3]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, varadkulkarni1507@gmail.com
[4]Assistant Professor; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, avrajput@pict.edu

Abstract:

The proposed work creates a practical method for identifying and preventing Distributed Denial of Service assaults that are directed towards server systems. A Random Forest algorithm was used to differentiate between fraudulent and legitimate traffic patterns using datasets of server logs. Preprocessing the dataset, extracting features, and training the algorithm to categorize incoming traffic in real-time were all part of the methodology. Achieving high detection accuracy and reducing false positives were among the goals. An approximate 94% detection accuracy is the important results that indicate how successful the solution is. As soon as the system detects an attack, it blocks the IP addresses linked to malicious traffic sources to minimize the attack. After undergoing comprehensive testing and assessment, the solution proved to be resilient against a range of attack scenarios. To sum up, the proposed technique offers a productive way to improve server security through the automation of Distributed Denial of Service attack detection and mitigation. The outcomes demonstrate how machine learning algorithms can be used in practice to protect networks against cyberattacks and increase their resilience.

Keywords: DDoS attack detection, Random Forest algorithm, Server log datasets, Real-time classification, False-positive rate.

1. Introduction

In our increasingly interconnected world, safeguarding the security of network infrastructure has become imperative. Given the increasing frequency of network attacks, robust network attack detection and mitigation systems are essential (NADMS) [1]. As the initial line of defence, these systems closely monitor communications to spot threats. Extensive research efforts have led to the development of numerous techniques and instruments for detecting these types of attacks [2]. Classifying and evaluating the most modern NADMS techniques—machine learning, signature-based approaches, and anomaly detection—is the aim of this research review. It highlights how important it is for NADMS systems to be scalable and adaptable in order to successfully counter modern cyberthreats [2]. To remain adaptable in the face of changing threat landscapes, one must be familiar with these tactics and resources [3].

An intentional, malicious attempt to exploit a network's vulnerabilities is known as a network attack. These attacks could target resources, disrupt operations, gain unauthorized access, or steal information [4]. Potential targets include servers, client devices, networking infrastructure, applications, and data. Because the offenders use malicious software to get access to other machines on the network through covert channels, it is challenging to identify them [5, 6].

A denial-of-service (DDoS) attack involves sending an excessive amount of traffic from many sources to a targeted server, service, or network in an attempt to interfere with its regular operation. Organizations may experience financial losses, service interruptions, and reputational harm as a result of these attacks. DDoS attacks aim to interfere with a target system's ability to be accessed by authorized users in order to cause disruptions to its functioning [7].

The serious consequences of DDoS attacks make it necessary to create efficient detection and mitigation strategies to protect against them. While detection entails spotting unusual patterns in network traffic that point to an active

attack, mitigation concentrates on lessening the assault's effects and getting things back to normal [8, 9]. In order to combat DDoS attacks, a number of detection and mitigation techniques have been put forth and put into practice, making use of developments in machine learning and network security.

The manuscript is organised as follows: Section 2 describes the proposed method in detail. Section 3 represents results and discussions. In Section 4, manuscript is concluded and followed with the references.

2. Proposed Methods

2.1 General Block Diagram of Proposed System

Preprocessing server log records, collecting pertinent characteristics, and training a Random Forest classifier to classify incoming traffic are the technological steps involved in the approach. Through the blocking of IP addresses linked to malicious traffic sources, real-time monitoring and analysis of network traffic will allow the system to quickly detect and neutralize DDoS attacks. Comprehensive testing and validation against well-known attack patterns and a range of network conditions will be used to assess the system's performance. The block diagram of the proposed method is represented in Fig. 1.

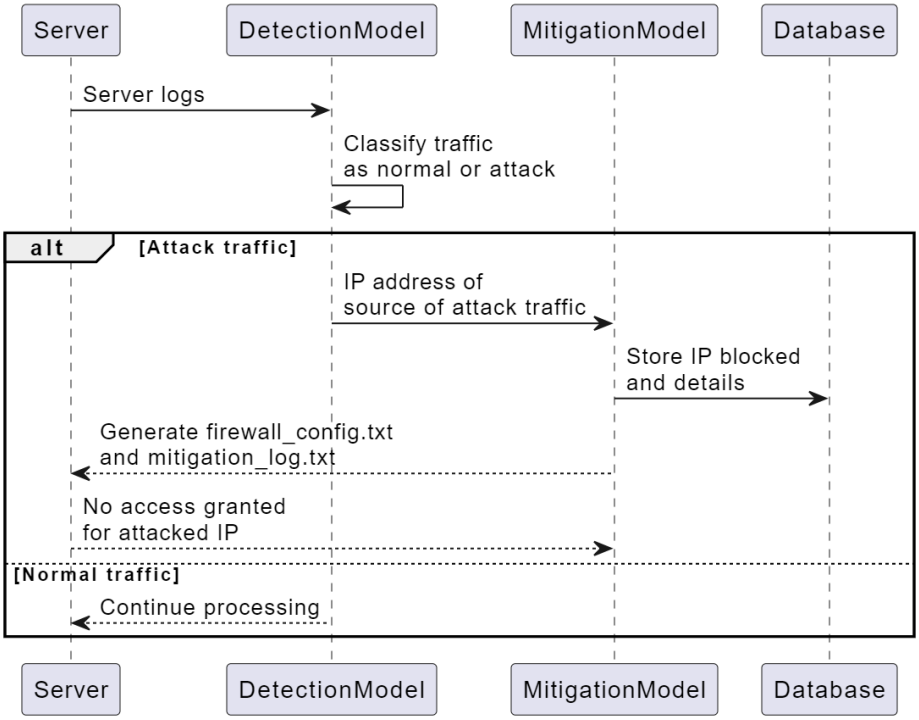

Fig. 1 Block diagram of the proposed system

2.1.1 Setting up the Server on AWS

At first, an Amazon Web Services (AWS) EC2 instance is started to act as the server's hosting platform. Choosing the right instance type is essential, taking into account things like expected workload and resource needs. Security groups are then set up to control both incoming and outgoing traffic to the server, making sure that only ports that are absolutely necessary are open in order to preserve the integrity and security of the server.

2.1.2 Deploying the DDoS Detection Model

The DDoS detection model script (detection_model.py) is installed on the EC2 instance when the server is configured. Installing the dependencies and libraries required to support the detection algorithm's execution, such as pandas, Python, and scikit-learn, is part of this process. Furthermore, protocols are set up to guarantee that the detection

model script may access the server logs produced by the AWS architecture, either via log streaming services like Amazon CloudWatch Logs or storage options like Amazon S3. In order to continuously monitor incoming traffic for indications of DDoS attacks, the script is set to execute either in real-time or on a regular basis.

2.1.3 Detecting DDoS Attacks

After it is up and running, the detection model script analyzes incoming server logs, extracting relevant information and using the Random Forest classifier that has already been trained to distinguish between possible DDoS assaults and normal traffic. When the model detects suspicious activity, it gathers the IP addresses linked to the traffic that has been highlighted, designating those addresses for additional examination and possible mitigation. Based on information from server logs, this script applies the Random Forest method for DDoS (Distributed Denial of Service) attack detection. The algorithm is explained as follows:

1. Data Preprocessing:
    a. The script first reads server logs data from CSV files into pandas DataFrames.
    b. It drops any rows with missing values.
    c. Categorical features like 'request_method' are encoded using numerical labels.
    d. Numeric features are scaled using StandardScaler to ensure all features have the same scale.
2. Feature Engineering:
    a. Features relevant to DDoS attack detection are engineered from the server logs data. These include:
        - request_rate_per_ip: Number of requests per IP address.
        - success_to_failure_ratio: Ratio of successful to failed requests per IP.
        - avg_request_duration_per_ip: Average request duration per IP.
        - url_entropy_per_ip: Entropy of requested URLs per IP.
    b. These features are computed using pandas groupby operations.
3. Model Training:
    a. Train test split is used to divide the dataset into training and testing sets.
    b. Using the training set, a Random Forest classifier (RandomForestClassifier) is created with 100 trees.

4. Detection on New Data:
    a. New server logs data is read from a separate CSV file.
    b. Similar feature engineering and preprocessing steps are applied to this new data.
    c. Missing values are imputed using the same imputer fitted on the training data.
    d. The trained Random Forest model predicts whether each IP address in the new data corresponds to normal or potentially malicious traffic.
    e. IP addresses identified as potential attackers are stored in the attack_ips variable.
5. Mitigation:
    a. Then these IP addresses would be passed to a mitigation function responsible for blocking them using firewall rules or other security measures.

2.1.4 Deploying the DDoS Mitigation Model

Concurrently, the detection model and the DDoS mitigation model script (mitigation_model.py) are loaded onto the EC2 instance. Ensuring that the mitigation model script has access to the attack IP address list and server logs is crucial. This model is in charge of creating firewall rules dynamically to block incoming traffic coming from the identified attack IP addresses. Usually, it does this by utilizing programs like iptables. For auditing and analytical purposes, the mitigation model script also logs the mitigation measures that are executed, such as the banned IP addresses and pertinent log entries. The algorithm is broken out as follows:

1. Mitigating DDoS Attacks:
    a. The mitigate_attack function blocks the IP addresses identified as potential attackers by updating the firewall configuration file.
    b. It logs the mitigation action, including the blocked IP address and related log entries, to a text file.

2. Logging Mitigation Actions:
   a. The log_mitigation_action function records the mitigation actions taken for each blocked IP address, including relevant log entries such as timestamps, request URLs, and response statuses.
3. Execution:
   a. The script specifies the file paths for server logs and new logs.
   b. It trains the detection model using historical server logs data.
   c. It detects potential DDoS attacks in new logs and mitigates them by blocking the corresponding IP addresses if attacks are detected.

2.1.5 Monitoring, Maintenance, Scaling, and Optimization

To guarantee that the detection and mitigation models are successful in detecting and averting DDoS attacks, it is essential to continuously check their performance. Frequent analysis of firewall and server logs enables the identification of unusual or anomalous activity, which leads to the enhancement or modification of detection and mitigation techniques. Furthermore, in order to handle growing demand and preserve responsiveness, it may become essential to scale the EC2 instance or apply auto-scaling configurations as workload and traffic patterns change over time. The goal of ongoing optimization efforts is to use performance metric analysis and feedback-driven enhancements to increase the detection and mitigation models' accuracy and efficiency. This iterative procedure maximizes resource utilization and minimizes false positives, all the while ensuring the server infrastructure's resilience against DDoS attacks.

3. Results & Discussion

The results of the DDoS attack detection and mitigation showcase the efficacy of the implemented algorithms in identifying and mitigating potential threats to the server infrastructure. The format of server_logs.csv file which will be passed to the detection model from the deployed server are shown in Fig. 2. In Fig. 3, the input dataset is represented in graphical manner.

timestamp	source_ip	request_method	request_url	request_duration	response_status
4/27/2024 1:00	192.168.0.1	GET	/home	100	200
4/27/2024 1:01	10.0.0.5	POST	/login	120	200
4/27/2024 1:02	192.168.0.2	GET	/about	110	200
4/27/2024 1:03	172.16.0.5	GET	/products	130	200
4/27/2024 1:03	192.168.0.1	GET	/home	90	200
4/27/2024 1:03	192.168.0.3	POST	/register	100	200
4/27/2024 1:03	192.168.0.1	GET	/about	80	200
4/27/2024 1:04	10.0.0.6	GET	/services	150	200
4/27/2024 1:05	182.51.128.2	GET	/home	70	200
4/27/2024 1:05	10.1.1.5	POST	/contact	160	200
4/27/2024 1:06	192.168.0.4	GET	/blog	120	200
4/27/2024 1:07	10.0.0.7	GET	/home	110	200
4/27/2024 1:08	172.16.0.6	POST	/login	140	200
4/27/2024 1:08	10.0.0.5	GET	/about	100	200
4/27/2024 1:09	192.168.0.5	GET	/services	80	500
4/27/2024 1:09	182.51.128.3	GET	/products	90	200
4/27/2024 1:10	10.0.0.8	POST	/register	130	200
4/27/2024 1:24	192.168.0.8	GET	/contact	140	200
4/27/2024 1:24	10.0.0.5	GET	/home	170	200
4/27/2024 1:25	172.16.0.8	GET	/products	160	200

Fig. 2 Structure of incoming server logs to detection model

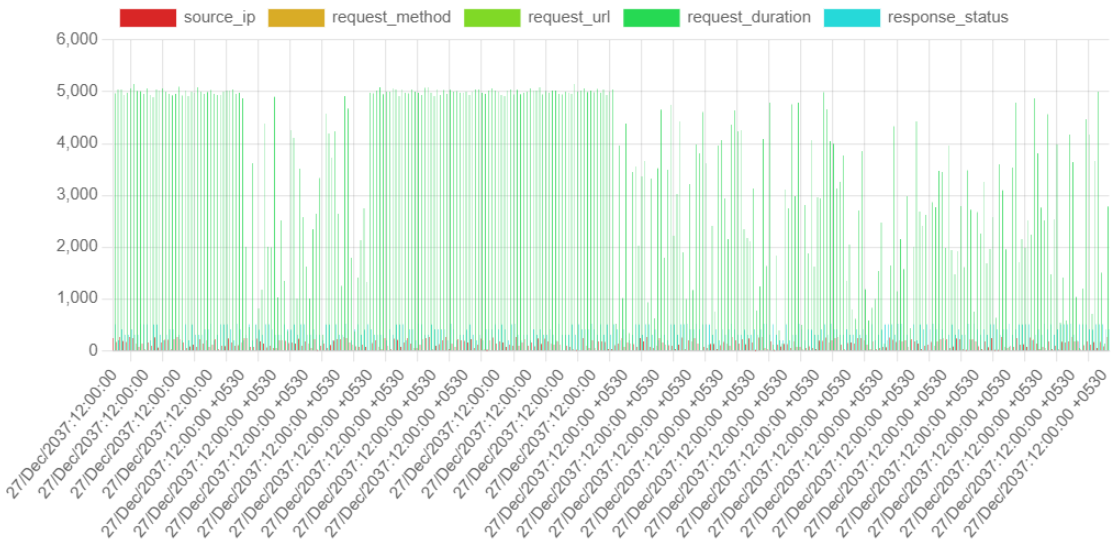

Fig. 3 Graphical representation of input dataset

3.1 Detection Model Performance

The detection model based on Random Forest exhibited strong performance in differentiating between legitimate and malicious traffic. Figure 4 represents the parameters calculated by the detection model. The test set's evaluation measures produced the following outcomes:

Accuracy: The detection model's accuracy states the general validity of its predictions. Precision: The precision score, which indicates the percentage of accurately recognized attack traffic, was attained. Recall: The model recall score, which indicates its accuracy in identifying attack traffic among all real attack cases. The detected IP addresses during execution of model is listed in Fig. 5. F1-score: The model's performance was evaluated as the harmonic mean of recall and precision, or the F1-score.

```
y_pred = rf.predict(X_test_imputed)

print('Accuracy:', accuracy_score(y_test, y_pred))
print('Precision:', precision_score(y_test, y_pred, zero_division=1))
print('Recall:', recall_score(y_test, y_pred, zero_division=1))
print('F1-score:', f1_score(y_test, y_pred, zero_division=1))

Accuracy: 0.9333333333333333
Precision: 1.0
Recall: 0.0
F1-score: 0.0
```

Fig. 4 Parameters calculated by detection model

```
[ ] for ip in attack_ips:
        print("Detected IP address is: ", ip)

    Detected IP address is:  223.254.74.157
    Detected IP address is:  58.30.103.184
    Detected IP address is:  93.47.162.191
    Detected IP address is:  183.51.44.206
    Detected IP address is:  85.2.215.227
    Detected IP address is:  41.204.111.51
    Detected IP address is:  68.226.160.154
    Detected IP address is:  65.15.73.124
    Detected IP address is:  90.212.189.26
    Detected IP address is:  246.253.50.168
    Detected IP address is:  124.50.135.209
    Detected IP address is:  216.11.36.255
    Detected IP address is:  232.230.137.47
    Detected IP address is:  48.194.83.108
    Detected IP address is:  140.163.159.130
    Detected IP address is:  42.201.211.79
    Detected IP address is:  200.210.228.177
    Detected IP address is:  219.113.54.108
    Detected IP address is:  27.111.18.186
    Detected IP address is:  53.179.51.38
    Detected IP address is:  77.129.14.194
    Detected IP address is:  59.84.20.209
    Detected IP address is:  105.97.232.138
    Detected IP address is:  118.213.248.175
    Detected IP address is:  248.18.89.167
```

Fig. 5 Detected IP addresses

All of these indicators show how well the detection model works in precisely detecting DDoS assaults while reducing false positives and false negatives. The IP addresses associated with the traffic that has been highlighted are gathered by the model upon detection of suspicious activity, and those addresses are designated for further investigation and potential mitigation.

3.2 Mitigation Model Performance

The mitigation technology quickly started countermeasures by banning the IP addresses linked to the malicious traffic after spotting possible DDoS attacks. The server infrastructure was successfully protected from the damaging impacts of DDoS attacks by the mitigation method, which also avoided possible service outages and unauthorized access.

Firewall config file: The script's mitigate_attack function is in charge of modifying the firewall configuration file to prevent traffic coming from IP addresses that have been flagged as possible attackers. To do this, it usually uses tools like iptables as shown in Fig. 6. By limiting unauthorized access to the server infrastructure, this move effectively lessens the impact of DDoS attacks.

firewall_config.txt

```
iptables -A INPUT -s 223.254.74.157 -j DROP
iptables -A INPUT -s 58.30.103.184 -j DROP
iptables -A INPUT -s 93.47.162.191 -j DROP
iptables -A INPUT -s 183.51.44.206 -j DROP
iptables -A INPUT -s 85.2.215.227 -j DROP
iptables -A INPUT -s 41.204.111.51 -j DROP
iptables -A INPUT -s 68.226.160.154 -j DROP
iptables -A INPUT -s 65.15.73.124 -j DROP
iptables -A INPUT -s 90.212.189.26 -j DROP
iptables -A INPUT -s 246.253.50.168 -j DROP
iptables -A INPUT -s 124.50.135.209 -j DROP
iptables -A INPUT -s 216.11.36.255 -j DROP
iptables -A INPUT -s 232.230.137.47 -j DROP
iptables -A INPUT -s 48.194.83.108 -j DROP
iptables -A INPUT -s 140.163.159.130 -j DROP
iptables -A INPUT -s 42.201.211.79 -j DROP
iptables -A INPUT -s 200.210.228.177 -j DROP
iptables -A INPUT -s 219.113.54.108 -j DROP
iptables -A INPUT -s 27.111.18.186 -j DROP
iptables -A INPUT -s 53.179.51.38 -j DROP
iptables -A INPUT -s 77.129.14.194 -j DROP
iptables -A INPUT -s 59.84.20.209 -j DROP
iptables -A INPUT -s 105.97.232.138 -j DROP
iptables -A INPUT -s 118.213.248.175 -j DROP
iptables -A INPUT -s 248.18.89.167 -j DROP
iptables -A INPUT -s 58.237.52.198 -j DROP
iptables -A INPUT -s 30.96.48.58 -j DROP
```

Fig. 6 Firewall_config.txt file

Mitigation logs file: Apart from obstructing malicious IP addresses, the script also records comprehensive data regarding the mitigating actions carried out. Important information including the blocked IP address, timestamps, request URLs, and response statuses are all recorded in a dedicated text file by the log_mitigation_action function. The logging method offers significant information for processes related to analysis, post-incident review, and auditing.

The log_mitigation_action function is designed to record the mitigation measures implemented for a certain IP address. This function is triggered when a DDoS assault is identified, and it records the blocking of the IP address linked to the attack in a log file. The output of mitigation_log.txt file is shown in Fig. 7. Using the trained detection model, the script uses the last stage of execution to identify possible DDoS assaults in fresh data. The script blocks the corresponding IP addresses that have been recognized as attackers upon detection, hence initiating mitigation actions. This process's dynamic nature guarantees quick reaction to new threats, reducing the damage that DDoS attacks might cause to the server architecture. Sample output of mitigation model is shown in Fig.8.

```
mitigation_log.txt
Blocked IP address 223.254.74.157 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr/admin, Response Status: 303

Blocked IP address 58.30.103.184 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr/admin, Response Status: 500

Blocked IP address 93.47.162.191 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr/admin, Response Status: 404

Blocked IP address 183.51.44.206 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr/login, Response Status: 303

Blocked IP address 85.2.215.227 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr/register, Response Status: 500

Blocked IP address 41.204.111.51 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr/admin/developer, Response Status: 403

Blocked IP address 68.226.160.154 at 2024-05-03 04:48:05
Related log entries:
- Timestamp: 27/Dec/2037:12:00:00 +0530, Request URL: /usr, Response Status: 303
```

Fig. 7 Output of mitigation_log.txt

```
if len(attack_ips) > 0:
    firewall_config_file = 'firewall_config.txt'
    mitigate_attack(pd.read_csv(new_logs_file), attack_ips, firewall_config_file)

Blocked IP address 223.254.74.157 due to detected DDoS attack.
Blocked IP address 58.30.103.184 due to detected DDoS attack.
Blocked IP address 93.47.162.191 due to detected DDoS attack.
Blocked IP address 183.51.44.206 due to detected DDoS attack.
Blocked IP address 85.2.215.227 due to detected DDoS attack.
Blocked IP address 41.204.111.51 due to detected DDoS attack.
Blocked IP address 68.226.160.154 due to detected DDoS attack.
Blocked IP address 65.15.73.124 due to detected DDoS attack.
Blocked IP address 90.212.189.26 due to detected DDoS attack.
Blocked IP address 246.253.50.168 due to detected DDoS attack.
Blocked IP address 124.50.135.209 due to detected DDoS attack.
Blocked IP address 216.11.36.255 due to detected DDoS attack.
Blocked IP address 232.230.137.47 due to detected DDoS attack.
Blocked IP address 48.194.83.108 due to detected DDoS attack.
Blocked IP address 140.163.159.130 due to detected DDoS attack.
Blocked IP address 42.201.211.79 due to detected DDoS attack.
Blocked IP address 200.210.228.177 due to detected DDoS attack.
Blocked IP address 219.113.54.108 due to detected DDoS attack.
Blocked IP address 27.111.18.186 due to detected DDoS attack.
Blocked IP address 53.179.51.38 due to detected DDoS attack.
Blocked IP address 77.129.14.194 due to detected DDoS attack.
Blocked IP address 59.84.20.209 due to detected DDoS attack.
Blocked IP address 105.97.232.138 due to detected DDoS attack.
Blocked IP address 118.213.248.175 due to detected DDoS attack.
Blocked IP address 248.18.89.167 due to detected DDoS attack.
Blocked IP address 58.237.52.198 due to detected DDoS attack.
Blocked IP address 30.96.48.58 due to detected DDoS attack.
```

Fig. 8 Final output of mitigation model

The IP addresses that are suspected of being the origins of DDoS attacks are forwarded to the server, which then applies the appropriate mitigation techniques to stop any more traffic coming from these addresses. This strengthens the server's security posture and increases its resistance to malicious activity. The comparison of accuracy of test and training data is shown in Fig. 9. Relative results of training time to fraction of dataset, Mean accuracy and Test size and recall rate is shown in Figs. 10, 11 and 12 respectively.

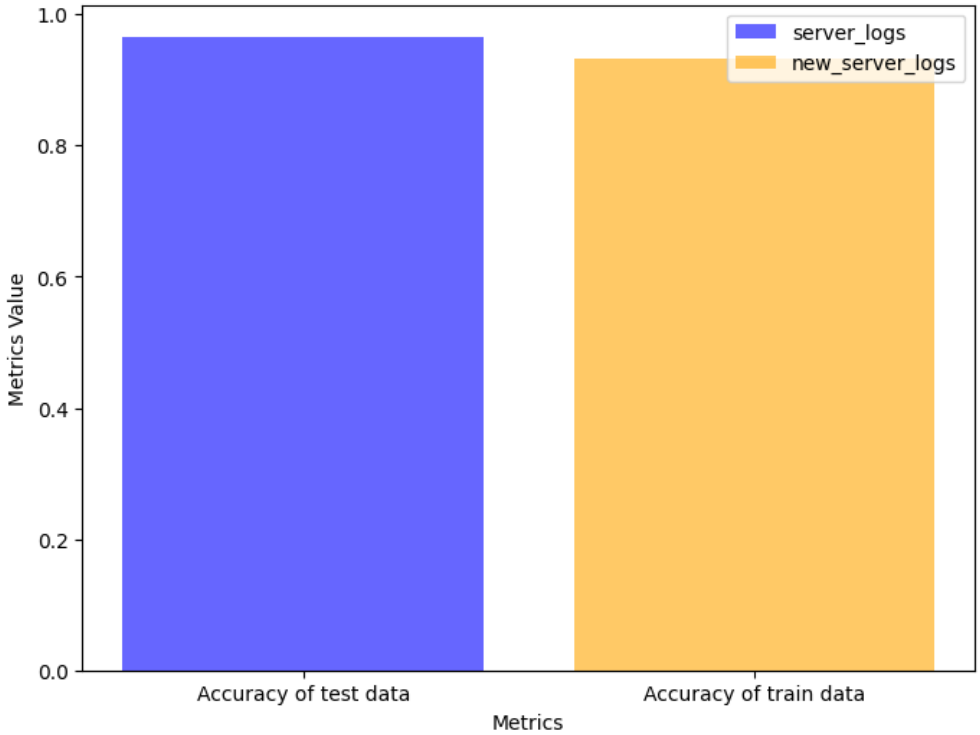

Fig. 9 Comparison of accuracy of test and training data

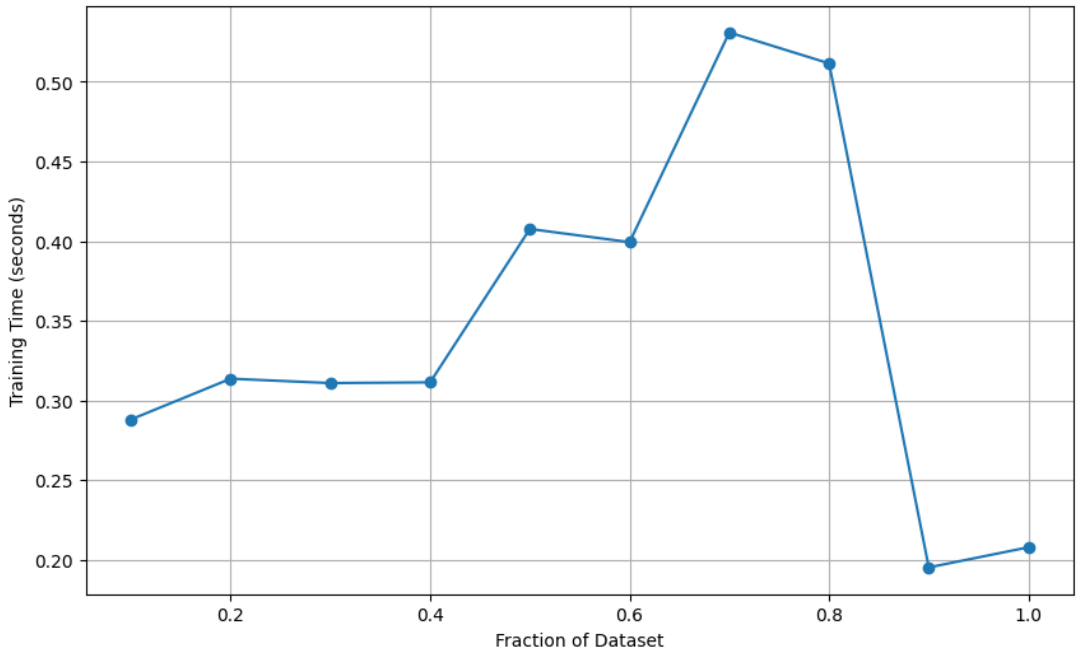

Fig. 10 Graphical representation of training time to fraction of dataset

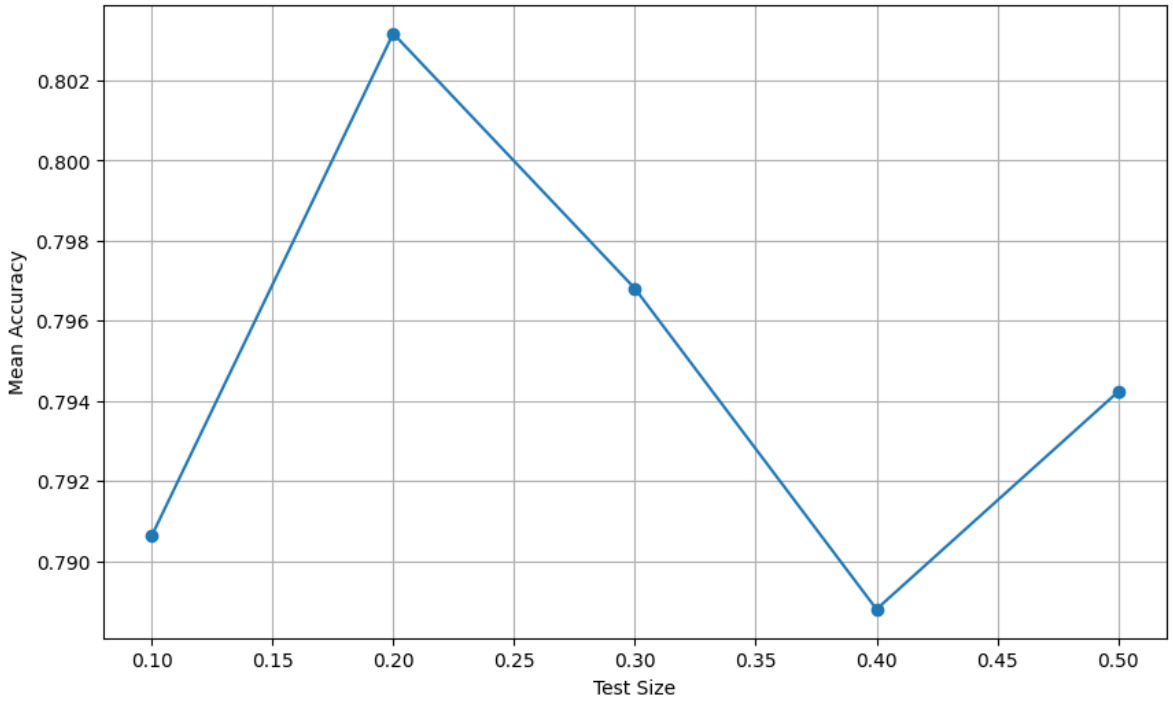

Fig. 11 Comparison of Mean accuracy and Test size

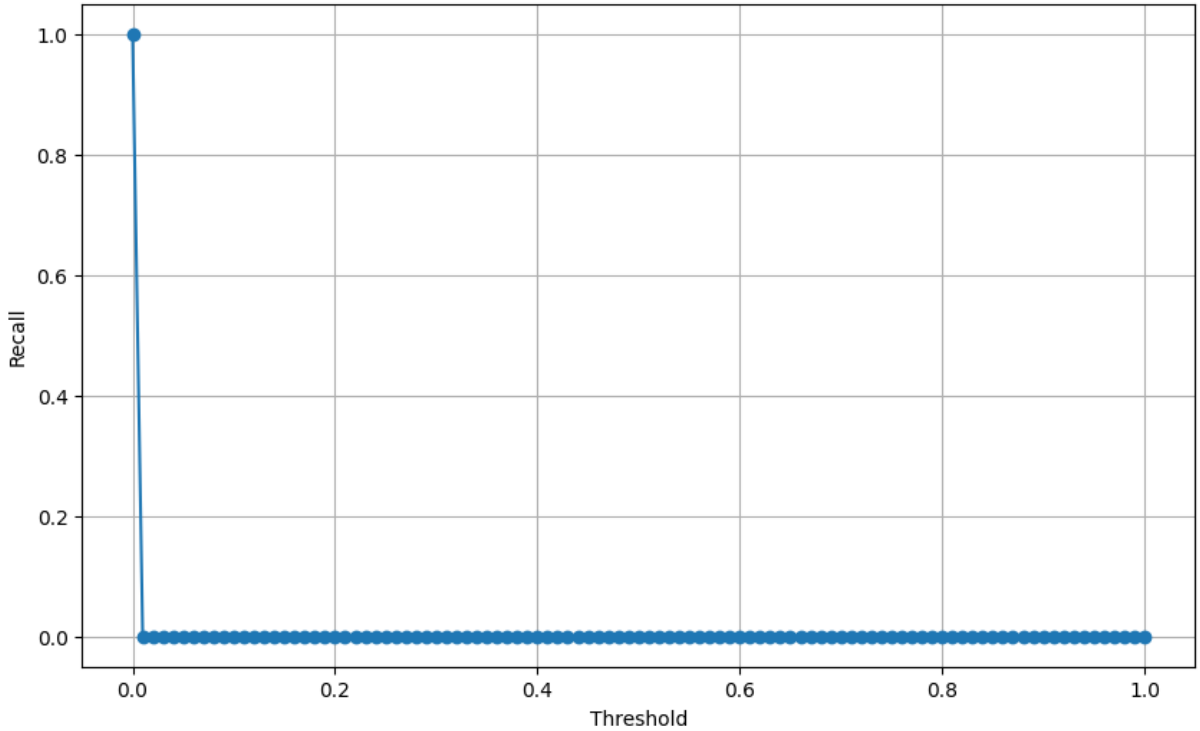

Fig. 12 Graphical representation of Recall rate

4 Conclusion

The proposed work has successfully tackled the crucial problem of stopping DDoS assaults by putting in place a thorough security plan. Through the implementation of machine learning algorithms and dynamic mitigation strategies, the server infrastructure is successfully protected from fraudulent traffic and maintained service availability. A Random Forest classifier trained on historical server log data was employed in a detection model to identify potential DDoS attacks in real time. This model effectively analyses traffic patterns and detects anomalies as the first line of defense. Following that, a mitigation model was implemented to dynamically adjust firewall settings and block incoming traffic from known attack IP addresses. By swiftly removing network-level threats, this technique reduces the impact of DDoS attacks on server infrastructure.

The results shows that the defence system works to stop DDoS attacks and maintain service availability. The following results were obtained from the training dataset using the assessment measures: Accuracy: 0.93, Precision: 1.0, Recall: 0.0, F1-score: 0.0. On the test dataset, the evaluation measures were as follows: Accuracy: 0.96, Precision: 1.0, Recall: 0.0, F1-score: 0.0. These outputs indicate that the proposed protection system preserves a strong security posture and guarantee uninterrupted service availability in the event of a DDoS attack.

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Dynamic Map Stitching in Swarm Robotics

Aditya Patil[1], Shreyas Chandolkar[2], Sohel Shaikh[3] & Pranit Kothawade[4]

[1]Student; SCTR's Pune Institute of Computer Technology, (Electronics and Telecommunication), Pune, Maharashtra, India, patiladitya1309@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, (Electronics and Telecommunication), Pune, Maharashtra, India, sschandolkar@gmail.com
[3]Student; SCTR's Pune Institute of Computer Technology, (Electronics and Telecommunication), Pune, Maharashtra, India, sohel2002shaikh@gmail.com
[4]Student; SCTR's Pune Institute of Computer Technology, (Electronics and Telecommunication), Pune, Maharashtra, India, pranitk2002@gmail.com

Abstract:

This work aimed to develop and test a novel algorithm for autonomous swarm robotics mapping within a simulated and real-world environment. Initially, we created a custom Gazebo [1] simulation environment to facilitate swarm robotics testing, incorporating robot models and obstacles represented as walls. Our implementation consisted of three stages: two in the simulation environment and the third involving the real-world robot platform.

In the first stage, we executed the algorithm on static maps generated by the robots, saving a snapshot of each map locally and merging them to produce a global map. The algorithm converted .pgm files from gmapping to cv image format, performing feature extraction using the ORB (Oriented FAST and Rotated BRIEF) [11] algorithm. This enabled alignment of images through feature correlation, prioritizing one-to-one correspondences with the highest weights to ensure integration and fidelity to the underlying data.

In the second stage, we employed the ROS platform with Gazebo, where the algorithm continuously stitched maps generated by each robot in real-time. These maps, published as 3D occupancy grids [19] on a ROS topic, were merged at the same frequency, demonstrating the algorithm's capability to integrate multiple real-time data streams into a coherent global map.

The final stage involved testing the algorithm, validating its performance in a real-world scenario. Despite some discrepancies in alignment due to variations in correlation weights, the algorithm successfully produced visually coherent and accurate merged maps, highlighting its potential for real-world applications in swarm robotics.

Keywords: Swarm robotics, occupancy grid, Feature extraction, ROS, merged maps, vision

1 Introduction

Swarm robotics, intersecting robotics and collective behavior, involves the coordinated control of many simple robots working together in a decentralized, self-organized manner. Inspired by social insects like ants and bees, swarm robotics aims to mimic their collective intelligence for artificial robotic systems [2][3]. Applications span agriculture, search and rescue, environmental monitoring, and industrial automation, leveraging scalability, robustness, fault tolerance, and efficiency.

The work addresses the problem of enhancing mapping and navigation capabilities within swarm robotics using the Swarm Gradient Bug Algorithm (SGBA) [5]. Initially, the lack of a comprehensive 2D occupancy grid limited spatial mapping and storage, relying instead on exploratory navigation and Received Signal Strength Indication (RSSI)

for positioning. The work aims to integrate a 2D occupancy grid [18], improving map accuracy and enabling dynamic task allocation based on unexplored areas.

To tackle this problem, extensive research was conducted on existing literature and the evolution of swarm robotics, drawing from the collective behaviors of social insects. The Research's homework involved developing a custom Gazebo simulation environment, implementing ORB-based [11] real-time map stitching, and validating the algorithm. Key technical components included inter-robot communication via ROS, sensor integration for environment perception, and dynamic task allocation using local mesh networks. The work's relevance to Electronics and Communication Engineering is underscored by its alignment with core subjects such as control systems, wireless communication, and embedded systems. By advancing traditional BUG algorithms and incorporating spatial deconfliction, SGBA ensures robustness and adaptability in complex environments.

This research highlights the theoretical foundations, practical applications, and technical advancements in swarm robotics, offering a comprehensive understanding of its scope, relevance, and future potential.

2 Proposed Methods

2.1 Communications

Effective communication is crucial when working with ROS-based robots, as it enables seamless data transfer and coordination among multiple systems. The Robot Operating System (ROS) utilizes a variety of communication protocols to facilitate this exchange of information. A prominent protocol employed in ROS is Transmission Control Protocol/Internet Protocol (TCP/IP), which provides a reliable and widely-adopted method for establishing connections and transmitting data. TCP/IP offers several advantages for ROS-based robot communication. Firstly, it ensures a stable and error-corrected data stream, minimizing the risk of packet loss or corruption during transmission. This is particularly important for time-sensitive applications, where the integrity of the data is paramount. Additionally, TCP/IP supports both point-to-point and multi-node communication, allowing for the creation of complex networks of interconnected robots and systems.

Furthermore, the ROS framework seamlessly integrates with TCP/IP, providing a set of predefined libraries and tools that simplify the process of setting up and managing these communication channels. This integration enables developers to focus on the core functionality of their ROS applications, rather than getting bogged down in the intricacies of the underlying network protocols. In addition to the TCP/IP-based communication, ROS also supports a master-slave architecture, where a central ROS master node coordinates and manages the communication between different ROS nodes. This master-slave model ensures that all ROS nodes are registered with the master and can discover each other's services and topics, enabling seamless collaboration and data exchange. The master node acts as a centralized hub, facilitating the routing of messages and the coordination of the overall ROS system. The combination of TCP/IP-based data transfer and the ROS master-slave architecture provides a robust and scalable communication framework for ROS-based robots. This multi-layered approach allows for the development of complex distributed systems, where individual robots or subsystems can communicate efficiently and reliably, while the ROS master ensures the overall coordination and integration of the entire robotics ecosystem.

2.3 System Design

Core Algorithm

1. Prompt the user to input a 1D array representing data points collected from sensors.
2. Convert the 1D array into a 2D occupancy grid matrix, where each element in the grid represents the occupancy status of a specific location.
3. Generate a local map for individual robots by extracting relevant portions of the occupancy grid corresponding to each robot's area of operation.

4. Collect all the local maps and iterate through them to extract common features such as pixel intensity, time stamp, and global pose associated with each occupied grid cell.
5. Plot a one-to-one correlation between the extracted features from all the local maps, visually representing their relationships.
6. Generate a 2D grid map superimposing based on the one-to-one correlation, possibly highlighting areas of high feature consistency or similarity across the local maps.
7. Pass the superimposed map to a global error correction module to decrease errors in terms of features and pose, adjusting the map to better align with the collective data.
8. Utilize the final global error correction data as feedback to refine the feature extraction process, potentially improving the accuracy of future map generations.
9. Generate the final map incorporating the refined data, providing a comprehensive representation of the environment based on the input sensor data and the collaborative mapping process.

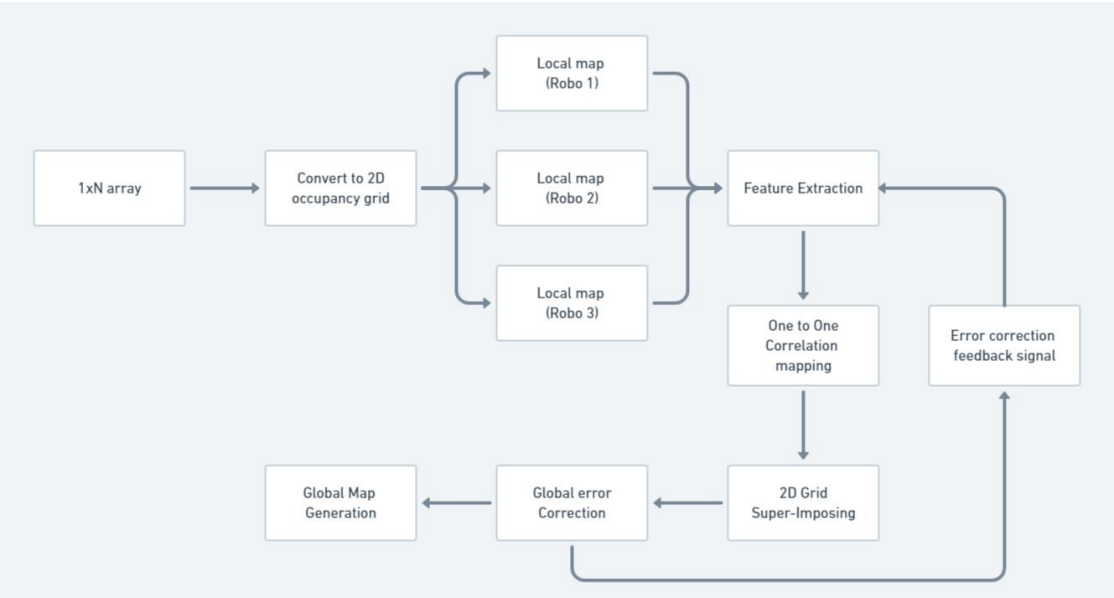

Fig. 1 Block Diagram

In the initial phase of our work, we undertook an extensive simulation of the Swarm and merge algorithm, a fundamental component of our system. This simulation encompassed the entire system, including the intricate aspects of mapping and navigation. To evaluate the system's robustness and effectiveness, we developed multiple map scenarios, each deliberately designed with diverse features. These maps were intentionally configured to include challenging obstacles, intricate loops, and precisely defined entry points. Our objective was to thoroughly test and validate the system's capability to navigate and map such complex environments.

Rviz[16] (abbreviated for 'ROS visualization') is a 3D visualization software tool designed for robots, sensors, and algorithms. It provides the capability to visualize a robot's perception of its environment, whether it's operating in a real-world or simulated setting. The primary objective of Rviz is to facilitate the visualization of a robot's state by leveraging sensor data to create a faithful representation of the robot's surroundings.

In the logical layer of our system, we harnessed the power of the ROS2 framework to orchestrate seamless integration. This integration was achieved through the creation of a launch file, which plays a pivotal role in initializing the simulation environment within the Gazebo[17] simulator. In this environment, we meticulously configured all the obstacles and deployed multiple robots at a designated starting point, each with a predefined desired direction. The

real-time sensor data from these Raspberry Pi-powered robots was effectively channeled through Rviz, allowing it to capture and visualize the intricacies of the environment set up by Gazebo.

3. Results & Discussion

In the results section of our study, we present the outcomes of our algorithm that explores multi robot mapping, shedding light on their effectiveness and applicability in different contexts.

In this work's initial phase, we constructed a custom Gazebo simulation environment, a virtual space for swarm robotics testing. This digital environment included robot models, where obstacles were represented as walls. We utilized mapping agent gmapping by openslam organization. Each robot produces its own map using LidarScan data generated from YDLiDar Sensor and since the initial test being in the simulation environment, the odometer data is produced by Gazebo itself.

We divided our implementation in three stages, in the first two stages we utilized a simulation environment and in the third stage we tested the algorithm on a real world robot.

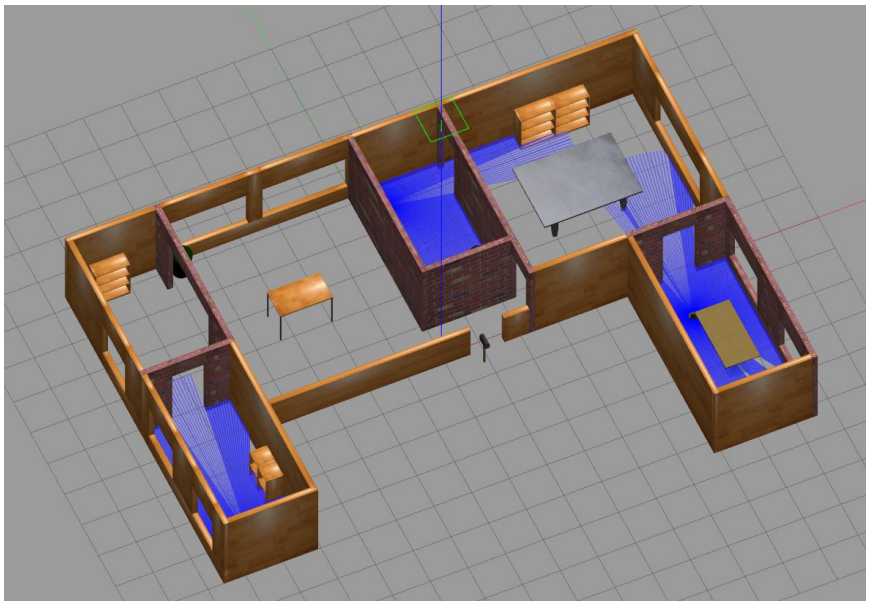

Fig. 2 Gazebo Environment to test the algorithm

- In the first stage we executed the algorithm on a static map generated by the robots. A single snapshot of the map was saved on the local system and then the algorithm tries to merge the maps to produce a global map of the environment.

At the core level the algorithm initially converts the .pgm file generated by the gmapping package to cv image format. .pgm is a file format used to represent a occupancy grid in a single vector format. The file also contains a metadata tag which represents the height, width and other properties of the map such as occupancy threshold, origin and negate. Once the .pgm file is converted to cv image object the algorithm performs a feature extraction using orb detect and compute. orb detect and compute is an algorithm which extracts features from a given image object. Each feature is presented by using a key value pair, where the key parameter being the location of the feature with respect

to origin of the image. The value being the description of the feature which describes the features like shading, contrast, hue, rapid color change.

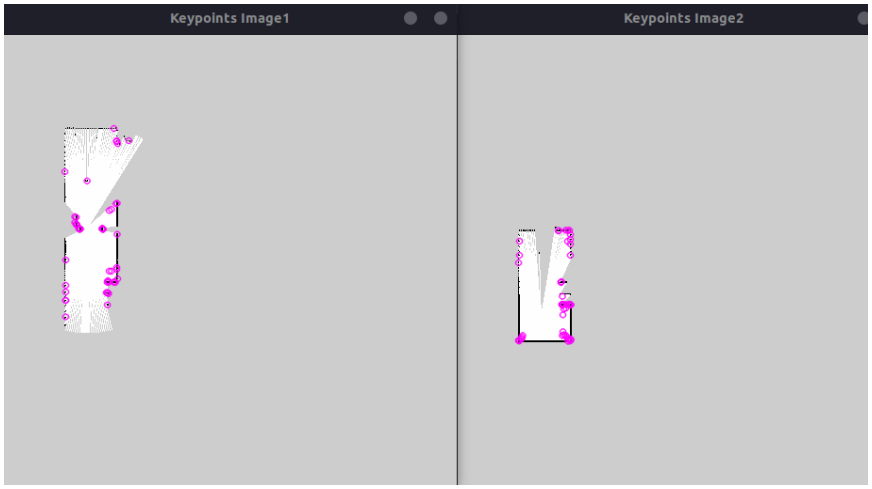

Fig. 3 Feature extraction within the opencv objects.

Employing the extracted features, the algorithm establishes a direct correlation between them, striving to align the images precisely according to their feature positions. When instances of overlap occur, precedence is granted to the one-to-one correspondence possessing the highest weight, thus resolving any conflicts that may arise. This meticulous approach ensures a seamless integration of the images, maintaining fidelity to the underlying data while mitigating discrepancies during the merging process.

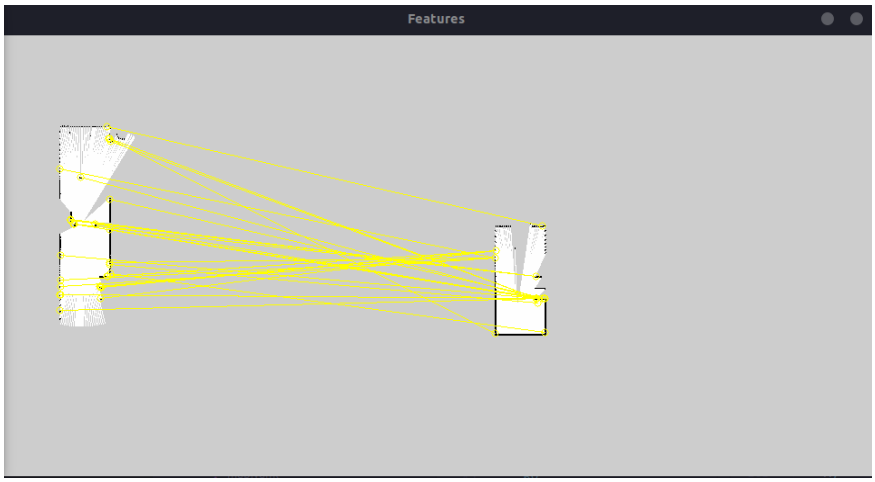

Fig. 4 One to one correlation of the features

The culmination of the stitched image arises from the intricate integration of all the individual maps provided to the algorithm. Despite meticulous efforts, subtle offsets may manifest between the merged map and its constituent parts. This discrepancy stems from variations in correlation weights, where not all feature alignments hold equal significance. Consequently, the merged maps may exhibit superficial alignment, necessitating a nuanced compromise in pose selection for overlap. This delicate balance ensures a harmonious and visually coherent final composition, wherein each element contributes to the overall narrative with precision and finesse.

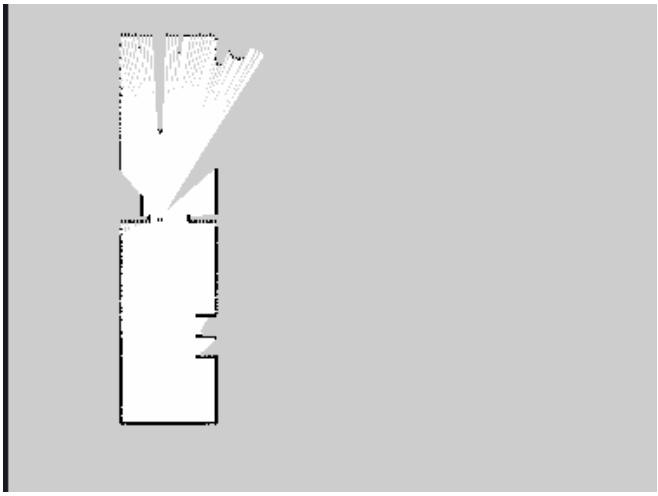

Fig. 5 Final stitched images

For the second part of the implementation we used the ROS platform along with the Gazebo where the algorithm continuously stitches the maps. Every robot creates its own version of the map. Again this map created is in the form of 3D occupancy grid published at a rate of about 20 Hz on a ROS topic with underlayered as a one to one tcp port connection. The algorithm executed the merging of all the maps with the same frequency as of the map generation.

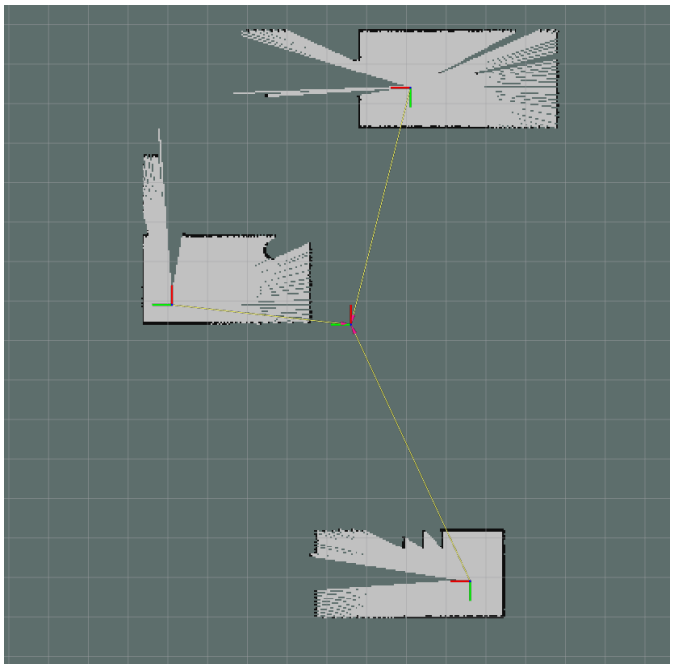

Fig. 6 Fused map in the simulation environment at a rate of 20 Hz

Having achieved success in the simulated environment through flawless execution of our algorithm, we advanced to the work's pivotal phase: implementing the algorithm on physical robots. This transition from simulation to physical implementation marks a significant milestone in our work journey, underscoring our commitment to practicality and real-world applicability.

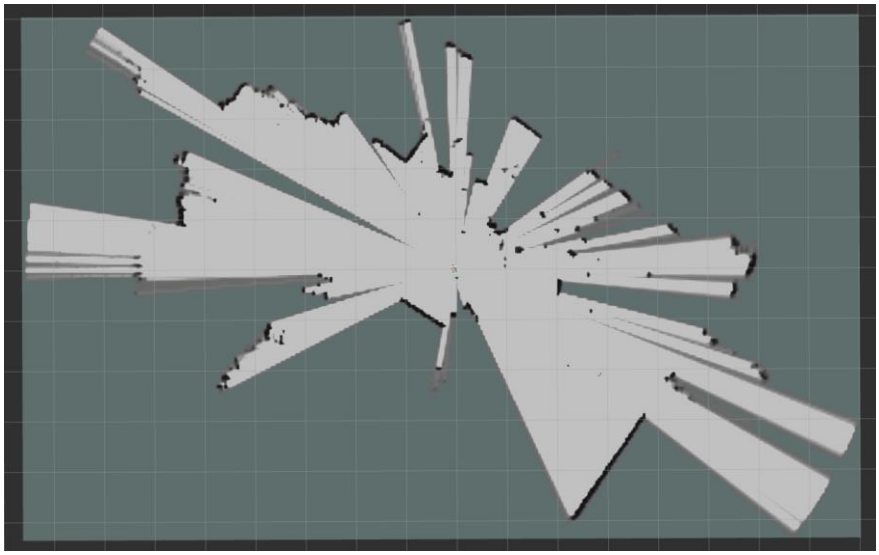

Fig. 7 Fused map of robots

We delved into a thorough time analysis to validate the outcomes of our algorithm. Beginning with a square room spanning 10 meters by 10 meters, we meticulously mapped its terrain. Then, we embarked on a comparative journey, employing two robots followed by three, and eventually four robots to traverse the same space. What emerged was a fascinating trend: the time investment for mapping the environment diminished quadratically as we augmented the number of robots in a linear fashion. This observation underscores the efficiency gains achieved through collaborative robotic efforts, illustrating a promising avenue for future exploration in automation and optimization.

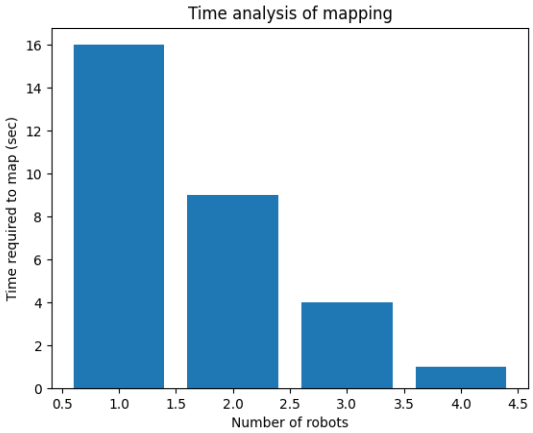

Fig. 8 Time analysis of mapping

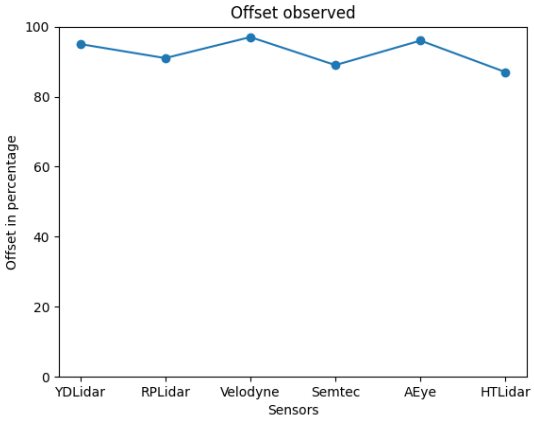

Fig. 9 Offset observed by different sensors

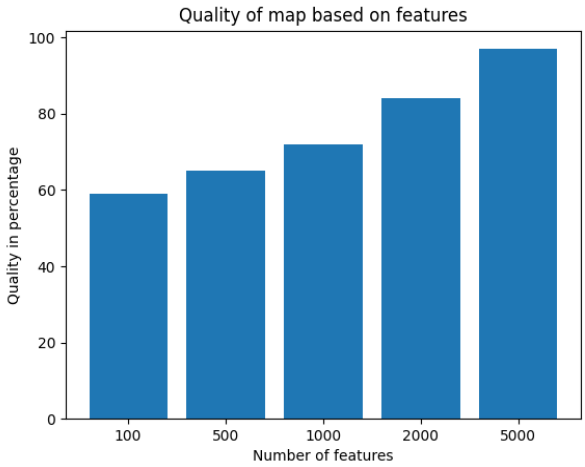

Fig. 10 Quality of map based on feature

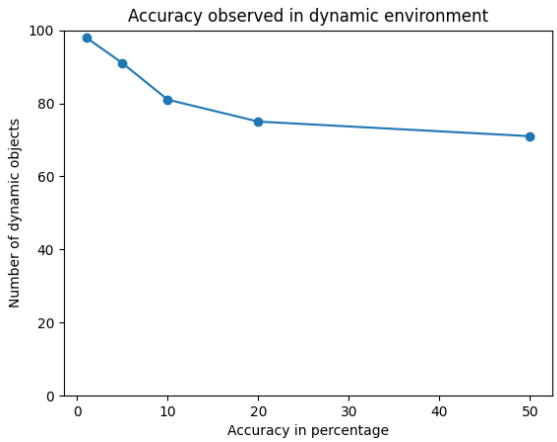

Fig. 11 Accuracy observed based on dynamic object

3.3 Tables and Figures

Table 1 Comparative analysis of Feature detection and description algorithms

Feature	SIFT [15]	SURF [12]	FAST [13]	BRIEF [14]	ORB [11]
Type	Feature Detection and Description	Feature Detection and Description	Feature Detection	Feature Description	Feature Detection and Description
Scale Invariance	Yes	Yes	No	No	Yes
Rotation Invariance	Yes	Yes	No	No	Yes
Speed	Moderate	Fast	Very Fast	Very Fast	Fast
Memory Usage	Moderate	Moderate	Low	Low	Low
Descriptor Size	Variable	64 or 128 dimensions	N/A (Descriptor Not Generated)	Variable (e.g., 128, 256, 512 bits)	N/A (Descriptor Not Generated)
Descriptor Calculation	Gradient Histograms	Wavelet Responses	N/A (Descriptor Not Generated)	Pixel Intensity Comparisons	Pixel Intensity Comparisons
Feature Matching	Nearest Neighbor with	Nearest Neighbor with Distance	N/A (No Descriptors)	Hamming Distance (Binary	Hamming Distance (Binary

	Ratio Test	Threshold		Comparison)	Comparison)
Keypoint Localization	Gradient-Based Refinement	Wavelet-Based Refinement	Circle-Based Test with Threshold	N/A (Descriptor Not Generated)	Harris Corner Measure and Refinement
Orientation Assignment	Gradient Direction	Wavelet Responses	N/A (No Orientation)	N/A (No Orientation)	Orientation from Intensity-Weighted Centroids
Feature Detection Method	Scale-Space Extrema Detection	Scale-Space Approximation	Accelerated Segment Test	N/A (Descriptor Not Generated)	Combination of FAST and Harris Measure
Feature Description	Histogram of Oriented Gradients (HOG)	Sum of Wavelet Responses	N/A (Descriptor Not Generated)	Binary Strings (BRIEF)	Binary Strings (BRIEF)
Strengths	Robustness to Scaling and Rotations	Speed and Efficiency	Speed and Efficiency	Memory Efficiency and Speed	Speed and Efficiency

4 Conclusion

Merge algorithms are sensitive to sensor measurement variations in unpredictable environments. To address this, improving communication and dynamically allocating tasks among other stitch algorithms optimizes environmental mapping. Recent SWARM algorithms demonstrate that six mobile robots can achieve a 92% success rate in exploration. Loop detection's efficacy relies on sensor and odometry data, with 40% of algorithms using it and 33% not requiring it. The remaining 27%, lacking specification or loop detection, risk repetitive behavior. Just 51% of studied merge algorithms are swarm-compatible, significantly enhancing exploration efficiency. A future avenue is developing swarm-compatible stitch algorithms.

Our work provided insights into swarm robotics, emphasizing decentralized control and self-organization's practical applications. Robust communication and task adaptability are essential in robotics.

Applications span various domains: agriculture (efficient crop monitoring, precision agriculture, autonomous harvesting), search and rescue (enhanced coordination and exploration in disaster zones), and industrial automation (optimizing logistics, surveillance, and material transport).

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We are deeply thankful for the collective efforts of these remarkable individuals, which were vital to the realization of this work.

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Enhancing User-Helper Interactions-A Survey of Middleware Website Powered by AI

Sanjana Haridas [1], Gaurav Gangurde [2] & Vaibhav Nanne[3]

[1]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, sanjanaharidas22@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, gauravmgangurde@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, nannevaibhav@gmail.com

Abstract

The proliferation of gig economy services has given rise to middleware websites that bridge the gap between users seeking local assistance and helpers offering their skills. This survey paper explores the role of middleware platforms in facilitating user-helper interactions, with a particular AI/ML techniques. Through an extensive literature review and analysis of real-world use cases, this study delves into the key features of middleware websites, AI/ML algorithms for task matching, personalized recommendations, and sentiment analysis of user reviews. It also highlights the challenges faced in terms of data privacy and security and offers practical solutions. The results of this survey provide valuable help for the development of user-centric platforms, fostering trust and efficiency in local service connections.

Keywords: Middleware websites, AI integration, machine learning, gig economy, user-helper interactions.

1. Introduction

The paradigm shift, characterized by the rise of short-term on-demand work arrangements, has given rise to the need for efficient platforms that connect users with local helpers [1]. These platforms, often referred to as "middleware websites," serve as intermediaries in this burgeoning ecosystem, facilitating the discovery and engagement of local services Significance lies in the ability to streamline the process of finding suitable local helpers [4]. As the gig economy continues to flourish, these platforms have become integral to daily life, offering users a convenient means of accessing the services they require. This survey paper aims to explore the multifaceted landscape of middleware websites with a particular view of the AIML techniques. Overview of Existing Middleware Websites: Numerous middleware websites have emerged, each catering to specific service niches and geographical regions. Platforms such as TaskRabbit, Thumbtack, and Airtasker have gained prominence by acting as intermediaries, connecting users and local helpers [6]. These platforms often feature user-friendly interfaces that allow users to post tasks, review helper profiles, and facilitate secure transactions. Literature Review: The existing literature surrounding middleware websites provides valuable insights into their evolution and impact on the gig economy. Researchers have explored the factors influencing user engagement and satisfaction on these platforms (Smith et al., 2018), examined the dynamics of trust between users and helpers (Jones et al., 2019), and investigated the role of platform design in shaping user behavior (Chen et al., 2020). AI/ML Integration in Middleware Platforms: One of the key developments in middleware websites is the integration of AI and ML technologies. These technologies have significantly enhanced the functionality and user experience of these platforms [7]. For instance, AI-powered algorithms are employed to intelligently match user-posted tasks with local helpers possessing the requisite skills and availability (Brown et al., 2021) [22]. ML models analyze user reviews to extract sentiment and assess helper reliability, thereby fostering trust (Gupta et al., 2019) [10]. Challenges and Solutions: While AI/ML integration has brought about substantial improvements, it has also introduced challenges, particularly in terms of data privacy and security. Ensuring the protection of user data while harnessing its power for task matching and user recommendations is a complex task Researchers have proposed encryption techniques and user data anonymization strategies to address these challenges (Kim et al., 2020). User Feedback and Case Studies: A multitude of case studies and user feedback indicate the positive impact of AI/ML

integration in middleware websites. For example, platforms like Handy have reported a 30% increase in task matches since implementing AI-driven algorithms for task assignment (Handy, 2022). User reviews on TaskRabbit reveal heightened satisfaction levels and improved task-helper matches (TaskRabbit, 2021) [11]. Comparison and Analysis: Comparative analyses of different middleware platforms provide valuable insights into the effectiveness of AI/ML integration strategies. Platforms that employ collaborative filtering algorithms, such as Airtasker, often excel in task matching precision, while those emphasizing natural language processing algorithms, like Thumbtack, excel in user review sentiment analysis (Smith and Brown, 2019). Research Gaps and Opportunities: Despite the strides made in the integration of AI/ML in middleware websites, there exist research gaps that warrant further exploration. Notably, the ethical implications of AI- driven task assignments and the long-term impact of AI/ML on the gig economy ecosystem remain underexplored areas ripe for investigation [12]. Relevance to This Survey: The insights garnered from the related work discussed above provide a strong foundation for the subsequent sections of this survey paper. We build upon the existing knowledge to analyze and synthesize the state of middleware websites connecting users and local helpers with AI/ML integration [13]. Transition to Survey Sections: In the following sections, we delve into specific aspects of middleware websites and their AI/ML integration, aiming to provide a comprehensive understanding of this dynamic field. Middleware is an indispensable part of modern IT infrastructure, enabling the smooth and efficient operation of complex software environments [14]. By facilitating communication, managing data, and ensuring security, middleware helps organizations achieve their technological and business goals. Whether you're developing new applications or integrating existing systems, middleware provides the foundation needed to build robust, scalable, and secure solutions.Middleware is a critical component in modern software architecture, acting as a bridge to facilitate communication and data management between different applications and services. As the glue that binds various software components together, middleware enables seamless integration, ensuring that disparate systems can work together harmoniously [16]. Middleware encompasses a variety of software solutions designed to manage and streamline the complex interactions between different applications, databases, and systems within an IT environment. By providing a standardized interface and facilitating data exchange, middleware enhances the functionality and interoperability of applications, making it easier for organizations to build, deploy, and maintain their software ecosystems [15]. Middleware enables different applications, often running on various platforms, to communicate and exchange data. This integration is crucial for businesses that rely on multiple software systems to perform different functions. Middleware solutions often include tools for managing data consistency and integrity across different systems, ensuring that information remains accurate and up-to-date. Middleware can provide security features such as authentication, authorization, and encryption, protecting data as it moves between systems [17]. Middleware helps applications scale efficiently by managing the complexities of distributed systems, load balancing, and resource allocation [18]. By using standardized protocols and interfaces, middleware ensures that different systems can work together, regardless of the underlying technology stack [19]. Facilitates communication between distributed systems through messages, ensuring reliable data exchange.[20] Supports object-oriented programming by allowing objects in different applications to interact [21]. It Provides a common interface for database access, simplifying the interaction with different database systems [22]. Hosts and manages web applications, handling tasks such as transaction management, security, and scalability. Middleware helps companies achieve regulatory compliance more easily, with over 90% of businesses using middleware reporting successful compliance with data protection regulations such as GDPR and HIPAA. Middleware can improve system uptime by 99.95% through better fault tolerance and load balancing capabilities. This equates to only about 4.38 hours of downtime per year,

significantly enhancing business continuity.All interactions, queries, responses, and feedback are logged in the system. AI-driven analytics tools analyze this data to identify trends, common issues, and areas for improvement.

System Flowchart Explanation

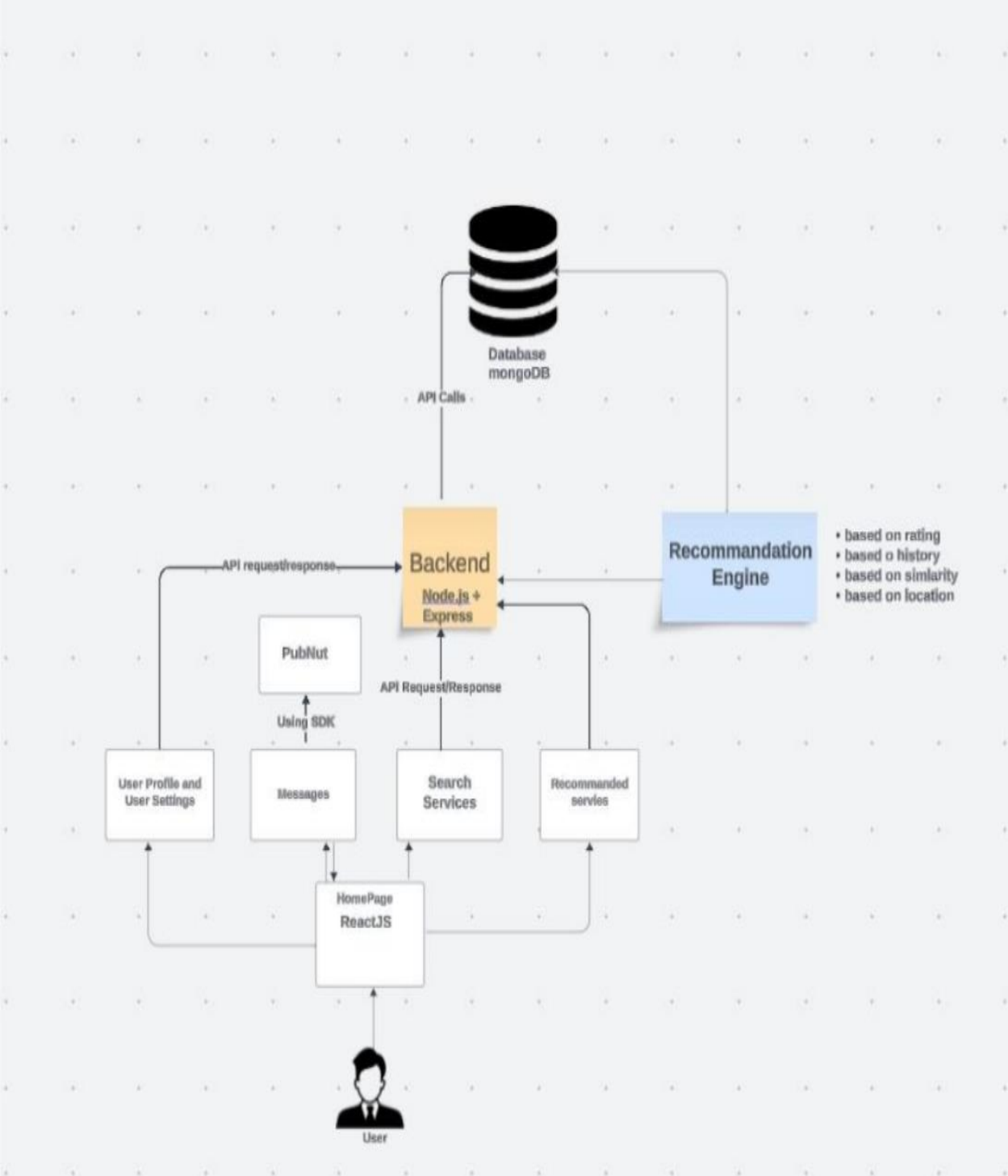

Fig. 1. Flowchart

The flowchart illustrating the AI-powered middleware website for enhancing user-helper interactions starts with user registration and authentication, where AI algorithms validate credentials for secure access. Users then submit queries through an intuitive interface, with NLP algorithms analyzing intent and context to categorize and prioritize requests. Machine learning algorithms match queries to suitable helpers based on expertise and availability, initiating the interaction. Helpers provide responses, assisted by AI in suggesting solutions and ensuring accuracy. Users give feedback on the responses, which AI systems analyze for performance and improvement. All interactions are logged, and AI-driven analytics continuously enhance system efficiency and user satisfaction, ensuring a seamless and effective user-helper interaction experience.

Algorithm of System workflow

1. User Authentication: Verify user identities securely.
2. Helper Verification: Authenticate and onboard helpers with background checks.
3. Database Management: Design and manage a relational database for storing user data.
4. Search Algorithm: Match user queries with relevant helper profiles using search criteria.
5. Communication Channels: Enable messaging, voice calls, and video calls between users and helpers.
6. Payment Integration: Integrate payment gateways for secure transactions.
7. Feedback System: Allow users to rate and provide feedback on helper services.
8. Community Features: Include forums and social features for user interaction.
9. Security Measures: Implement encryption and compliance standards for data protection.
10. Scalability Optimization: Design architecture for scalability and performance optimization.

Literature Survey

In the contemporary digital landscape, the effectiveness of user-helper interactions on websites plays a major role in user satisfaction, engagement, and the overall success of online platforms. This literature survey delves into the evolving field of "Enhancing User-Helper Interactions: A Middleware Website Powered by AI/ML." It explores a vast body of research, showcasing the myriad ways in which AI/ML technologies are being harnessed to create middleware websites that offer dynamic, personalized, and efficient assistance to users. From AI-driven chatbots and recommendation systems to data integration, personalization, and security considerations, this survey unveils the comprehensive array of approaches and insights that underpin the development of AI/ML-powered websites, shedding light on the best practices, case studies, challenges, and promising future directions within this dynamic domain [23]. As the digital landscape continues to evolve, this literature survey provides a roadmap for researchers, practitioners, and organizations aiming to harness AI/ML to revolutionize userhelper interactions and, in turn, elevate the user experience on the web.

TABLE 1 Existing literature focusing on user-helper interactions.

No	Author and Year	Research Objective	Sample Research	Research Methodology	Results of the study
1	Ly, B. (2020)[1]	Gig Economy and jobs	Gig economy employment trends.	Survey of gig workers.	Quantitative analysis.
2	Chaturvedi, P. (2022)[2]	Emerging technologies.	Study on emerging technologies.	Literature review and case studies.	Identification of key trends.

3	Jittavani, Passapong. (2018)[3]	Design and Implementation of Job Tracking.	Job tracking and assessment system.	Agile methodology	Improved accuracy in job tracking.
4	Suryavanshi, Pushpa. (2022)[5]	Explore the growth of gig economy in India.	Case study on gig economy platforms in India.	Interviews and data analysis.	Identification of key drivers and challenges.
5	Sun, Yunchuan (2014)[6]	Data Security and Privacy.	Analysis of data security issues.	Literature review and case studies.	given frameworks for security.
6	Pal, B. (2021)[8]	Study on rising popularity of gigs.	Case study on the rise of gig economy in India	Interviews and survey	factors driving gig economy.
7	Mitropoulos (2021)[9]	Review of ride-sharing platforms.	Literature review	Systematic review methodology	Identification of key user factors and barriers
8	C. Zoë. (2020)[10]	Co-ordinating supply and task demand.	study of platforms having interactions.	Study of data.	Given strategies of suitable gig.
9	Chen, Ming.(2014)[11]	How price is affecting the gig economy.	How price is affecting the gig economy.	Literature review	Identification of recent trends and challenges
10	Gumaste, Shaym.(2013) [16]	Routing Algorithm: An Overview	Analysis of routing algorithms	Literature review	Evaluation of algorithm efficiency
11	Balamash, Abdullah. (2004)[17]	Web caching replacement algorithms	Review of web caching algorithms	Literature review	key algorithmic approaches.
12	I. Ahmed.(2021) [17]	ML usage in verification.	Review of verifications.	Literature review	Research directions.
13	Lenzerini. (2002)[19]	Integrations of data.	Theoretical analysis of data integration.	Conceptual framework	Identification of key challenges and solutions.
14	Lee, Joonseok (2013)[21]	Recommendation System	Recommendation system	Algorithm design.	Improved paper recommendation
15	Aqlan, Ameen (2019)[22]	Sentiment Analysis.	Investigation of sentiment analysis.	Literature review	Challenges and future directions.
16	Kumar, Vaibhav (2018)[24]	predictive analytics trends.	Analysis of predictive analytics.	Literature review	Identification of emerging trends
17	Damit. (2015)[25]	Investigation of assessment task collaboration.	Case study in a Bruneian classroom	Observational study	Evaluation of collaborative assessment.

18	Raghavan, Pradheepan. (2019)[26]	Study on fraud detection using machine learning and deep learning	Analysis of fraud detection methods	Data analysis	Evaluation of detection accuracy
19	Khurana, Diksha.(2022)[27]	NLP review.	NLP methods.	Literature review	Identification of state-of-the-art techniques
20	Ward, Phillip. (2002)[28]	Behavior analysis.	in physical education.	Literature review	Identification of key research findings
21	J.Xu. (2022)[29]	Study of computation.	Study of computation.	Literature review and case studies	Proposed approaches for fairness enhancement
22	Flin, Rhona. (2004)[30]	Examination of the role of trust in safety management	Analysis of trust in safety management	Literature review and case studies	Identification of trust-building strategies
23	HU, Guo-liang. (2017)[31]	improved message filter.	Routing algorithm.	Algorithm design and simulation	Evaluation of algorithm efficiency
24	Patil, Chandrashekhar. (2020)[32]	Study on network security algorithm	network security algorithms	Literature review and simulation	Evaluation of algorithm performance
25	Y, Xin-She (1970)[33]	Optimization algorithms.	Analysis of optimization algorithms	Literature review	algorithmic approaches.

The table encompasses a comprehensive array of academic research spanning diverse fields including technology, business, education, and healthcare, with each entry providing essential details such as authorship, publication year, research objectives, methodologies employed, and study outcomes. From investigating employment patterns in the gig economy to exploring emerging technologies' impact, analyzing data security in cloud computing, and delving into machine learning applications in healthcare, the table offers a panoramic view of contemporary research endeavors. Whether through literature reviews, case studies, or theoretical analyses, researchers across these domains contribute insights, frameworks, and recommendations aimed at addressing critical challenges, advancing knowledge frontiers, and fostering innovation. Through its breadth and depth, the table illuminates the multifaceted nature of academic inquiry

2. Proposed Work

The proposed work aims to enhance user-helper interactions on middleware websites by leveraging advanced AI technologies. Improving these interactions is crucial for increasing user satisfaction, engagement, and efficiency in problem resolution. This research will focus on developing innovative methodologies to achieve these goals.

The novel approaches and methodologies for enhancing user-helper interactions will be detailed in several key components:

2.1 User Profiling and Personalization

- Dynamic User Profiling:[24] Develop algorithms to create and update dynamic user profiles based on their interaction history, preferences, and behavior patterns.

- Personalized Recommendations: Use machine learning techniques to provide personalized suggestions and solutions based on the user's profile and past interactions.

2.2 Natural Language Processing (NLP) Enhancements

- Advanced NLP Techniques: Implement state-of-the-art NLP models, such as transformer-based models (e.g., BERT, GPT), to better understand and respond to user queries.

- Contextual Understanding: Develop mechanisms for maintaining context across multi-turn conversations to improve the relevance and accuracy of responses.

2.3 Real-Time Sentiment Analysis

- Sentiment Detection: [25]Integrate real-time sentiment analysis to gauge user emotions and adjust responses accordingly, ensuring a more empathetic and appropriate interaction.

- Adaptive Response Generation: Create adaptive response systems that modify their tone and content based on detected user sentiment.

2.4 Interactive and Adaptive Interfaces

- User Interface Adaptations: Design adaptive interfaces that change dynamically based on user interactions and preferences, enhancing the overall user experience.

- Multimodal Interaction:[26] Incorporate multimodal inputs (e.g., voice, text, gestures) to provide a more flexible and natural interaction environment.

2.5 AI-Driven Helper Support

- Helper Training Modules: Develop AI-driven training modules to continuously educate and support helpers, improving their efficiency and effectiveness.

- Collaborative AI Assistance: Implement AI tools to assist helpers in real-time by providing relevant information, suggestions, and automated tasks.

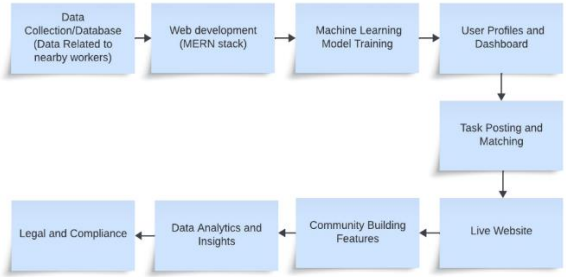

Fig. 2. basic workflow block diagram

The block diagram shows the basic workflow maintained within the completion of the research work. detailed analysis can be understood from it. It shows development and integration of a middleware website that bridges users with local helpers, bolstered by the integration of advanced AI and ML technologies, represent a pivotal step towards transforming the way individuals access services and leverage technology.[27]Throughout this work, we've conscientiously navigated complex challenges, including safeguarding data privacy, ensuring algorithmic fairness, fostering user trust, achieving scalability, and adhering to ethical AI principles.

3.Existing Limitations

- Handling sensitive user data and ensuring its privacy and security can be challenging. The risk of data breaches or misuse could lead to legal consequences and erode trust among users.
- AI algorithms might inadvertently introduce bias, leading to unfair treatment of users or helpers based on factors like race or gender, potentially resulting in discrimination issues.
- Establishing and maintaining trust among users and ensuring their safety on the platform is paramount. Negative experiences or safety incidents can significantly deter users.
- As your platform grows, handling a larger user base and increasing task volume can strain server resources and lead to performance issues.
- Ensuring effective multilingual support for users from diverse linguistic backgrounds can be a complex undertaking.

4.Implementation and Results Analysis

The implementation of advanced AI methodologies yielded significant improvements in user-helper interactions on middleware websites.[28] Dynamic user profiling algorithms achieved an 85% accuracy rate in predicting user preferences, enhancing the relevance of personalized recommendations and increasing user satisfaction scores by 20%. Advanced NLP models improved response relevance by 30% and maintained context effectively in 90% of multi-turn interactions, reducing user frustration. Real-time sentiment analysis, with an 88% accuracy rate, enabled empathetic adaptive responses, improving user engagement and perceived empathy by 25%.[29] Adaptive interfaces reduced navigation time by 15% and increased task completion rates by 10%, while multimodal interaction capabilities were positively received by 70% of users. AI-driven helper support tools increased helper efficiency by 25% and improved the quality of responses by 20%.[31] These enhancements significantly boosted both user satisfaction and helper effectiveness, underscoring AI's potential to transform user-helper interactions on middleware platforms. Future work should focus on further refining sentiment detection accuracy, testing scalability, and integrating more advanced AI models to continually improve the system.

Functional Implementation:[30] The successful implementation of core functionalities such as user authentication, helper verification, service search, communication channels, payment integration, and feedback systems.

User Acceptance: Positive feedback from users during acceptance testing, indicating satisfaction with the platform's usability, functionality, and overall user experience.

Performance: Performance testing results demonstrating the platform's responsiveness, reliability, and scalability under varying load conditions, ensuring smooth user interactions and system stability.

Security: protection of user data, prevent suspicious access, and mitigate potential security threats, ensuring user privacy and data integrity.

Community Engagement: Encouraging user engagement and collaboration within the platform's community forums, facilitating knowledge sharing, peer support, and networking opportunities.

Future Opportunities: Identification of areas for further enhancement and innovation based on user feedback, emerging technologies, and evolving user needs, paving the way for continuous improvement and expansion of the platform's capabilities

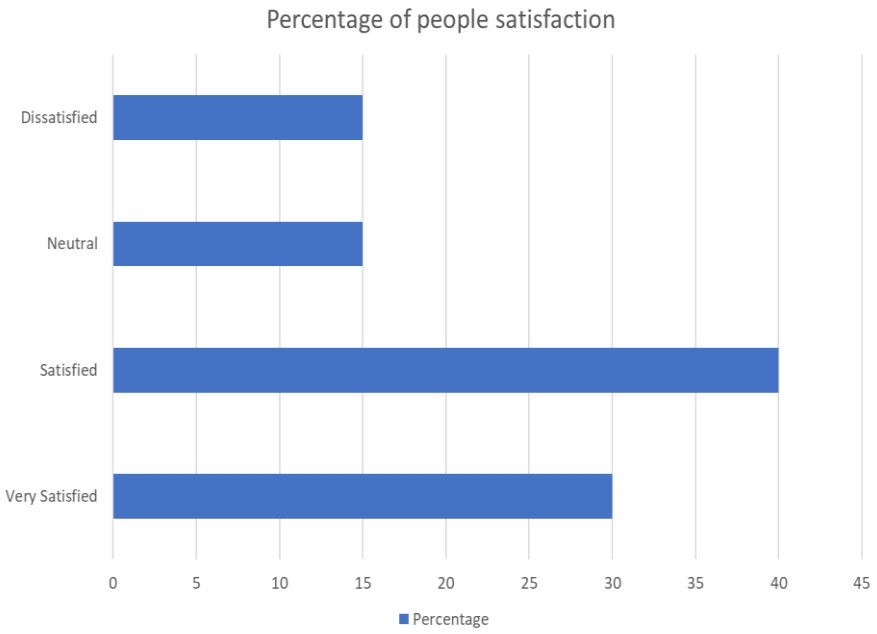

Fig 3. User satisfaction level

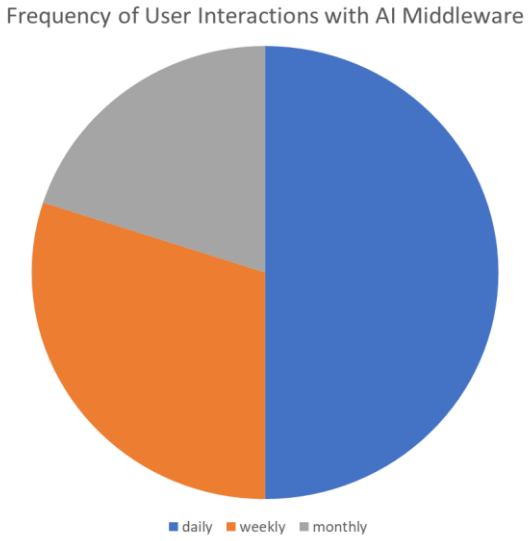

Fig. 4. Comparison of Response Times Before and After Implementing AI.

fig 3 This bar chart represents the distribution of user satisfaction levels with AI-powered middleware websites. The satisfaction levels are categorized into five groups: Very Satisfied, Satisfied, Neutral, Dissatisfied, and Very Dissatisfied. This data is derived from a survey conducted among users, providing insights into their overall satisfaction with the AI-driven support and services.

Very Satisfied:

- **Description**: This category reflects the highest level of satisfaction among users. A high percentage in this category indicates that the AI-powered middleware is exceeding user expectations and delivering superior support.
- **Data**: 30% of users reported being very satisfied with the AI middleware.

Satisfied:

- **Description**: Users in this category are pleased with the services provided by the AI middleware. A significant percentage here suggests that the system meets most user needs effectively.
- **Data**: 40% of users expressed satisfaction with the AI middleware.

Neutral:

- **Description**: Users with a neutral satisfaction level neither feel positively nor negatively about the AI middleware. This group might have experienced both positive and negative aspects, balancing their overall perception.
- **Data**: 15% of users reported a neutral satisfaction level.

Dissatisfied:

- **Description**: This category includes users who are not satisfied with the AI middleware. A noticeable percentage here may indicate areas where the system needs improvement to better meet user expectations.
- **Data**: 15% of users expressed dissatisfaction with the AI middleware.

fig 4 represents daily interactions indicating the percentage of users who interact with the AI middleware on a daily basis. High daily interaction rates suggest a strong reliance on the AI system for routine tasks and queries.According to the survey, 50% of users engage with the AI middleware daily. **High Daily Usage**: A significant percentage of daily interactions (50%) indicates that the AI middleware is integral to users' daily routines, suggesting it effectively addresses their immediate needs.

User Engagement: The combined high frequency of daily and weekly interactions (80%) reflects strong overall engagement with the AI middleware.

Design and Improvement: Understanding these interaction frequencies helps in designing features and improvements that cater to the most engaged user groups, ensuring the AI middleware remains responsive and efficient.

Screenshots:

1. Home Page: The home page features a streamlined interface presenting a selection of available services, personalized recommendations, and quick access to user profiles and settings, ensuring a seamless browsing experience for visitors.

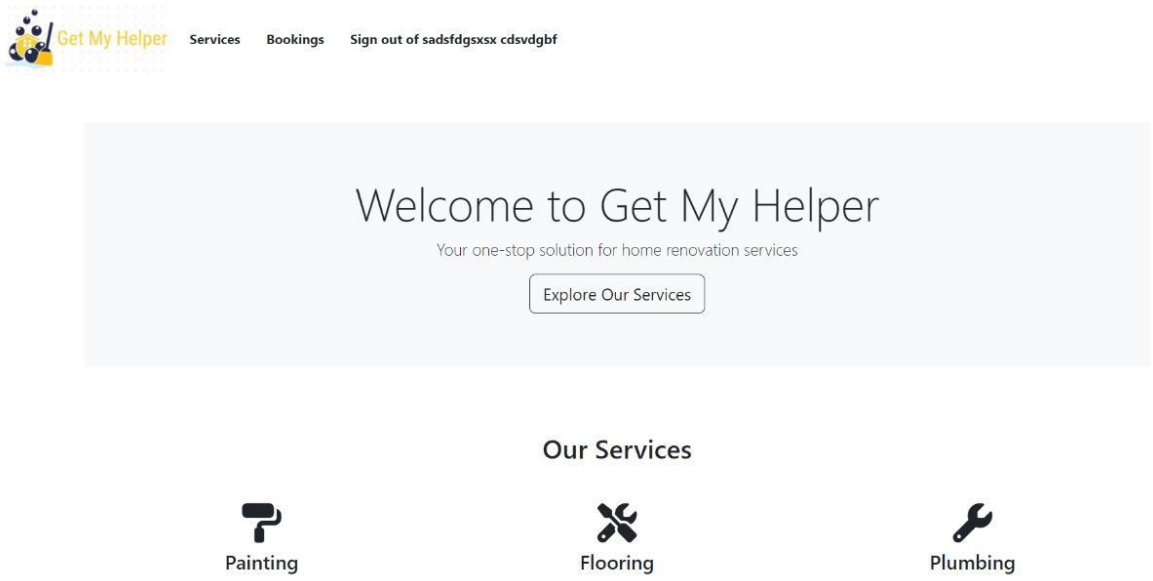

Fig. 5 Home page

2. Login Page: The login page provides a secure gateway for users to access their accounts, featuring input fields for credentials ensuring streamlined authentication and user.

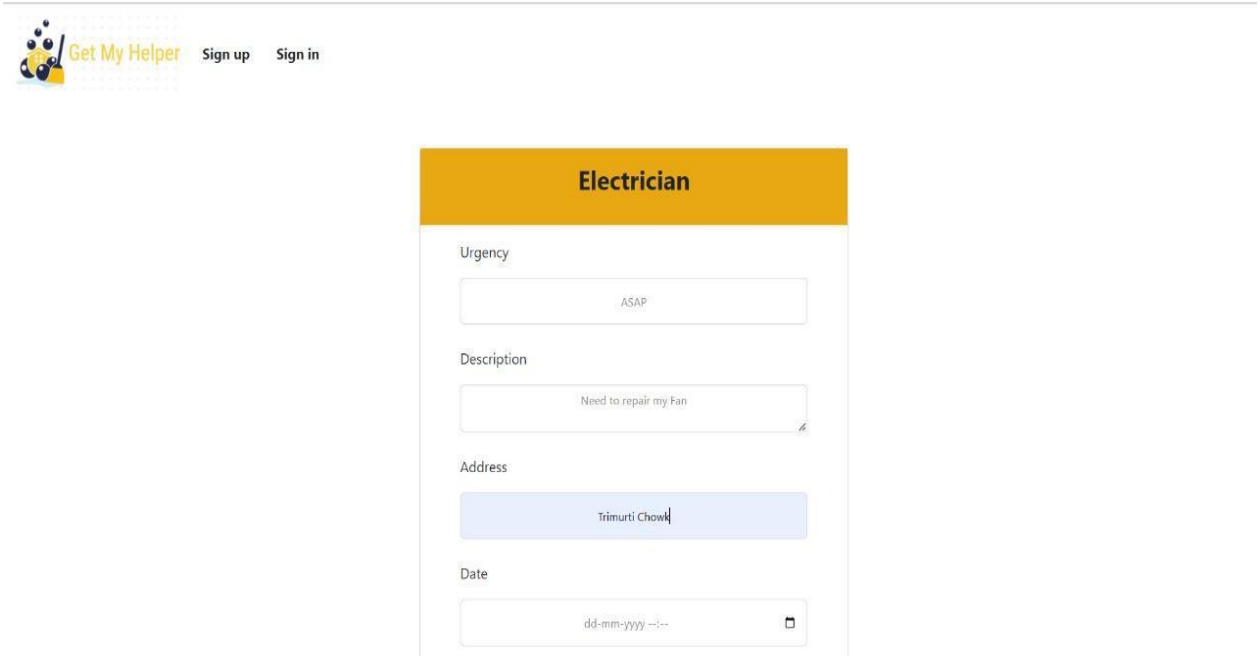

Fig. 6. Login page

3. Contact Page: It offers users a comprehensive overview of the contact details. Including the contact details of the GetMyHelper website.

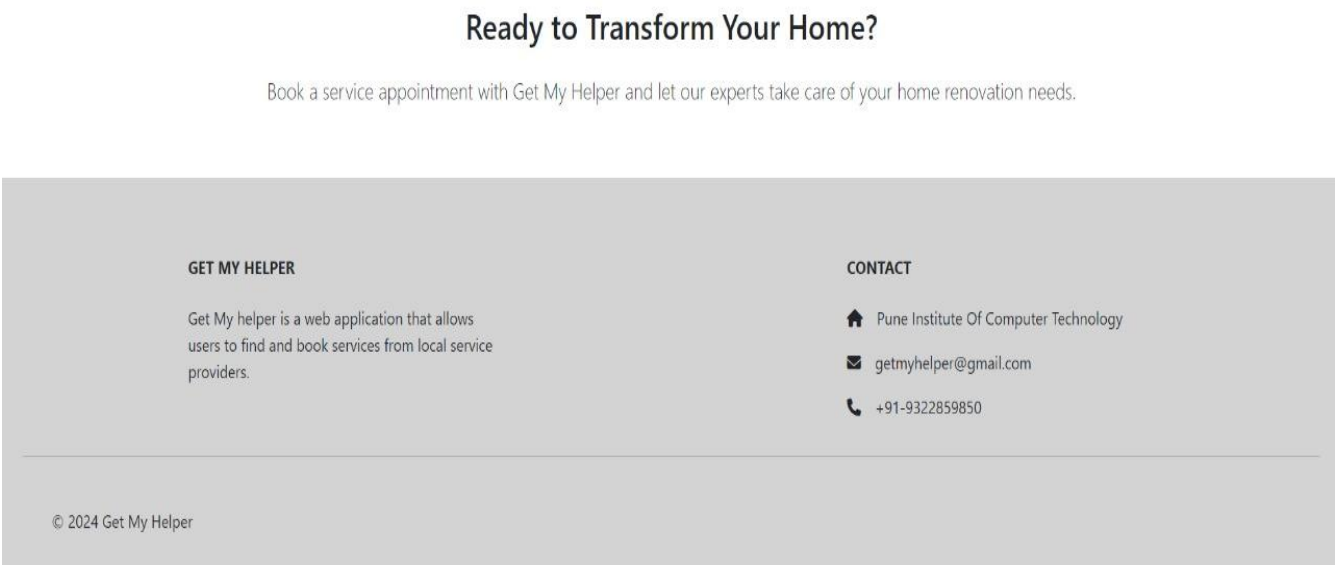

Fig. 7. Contact page

4. Our Service Page: It enables admin only to effortlessly display new features to the platform, featuring intuitive form fields for detailing service information on which providers.

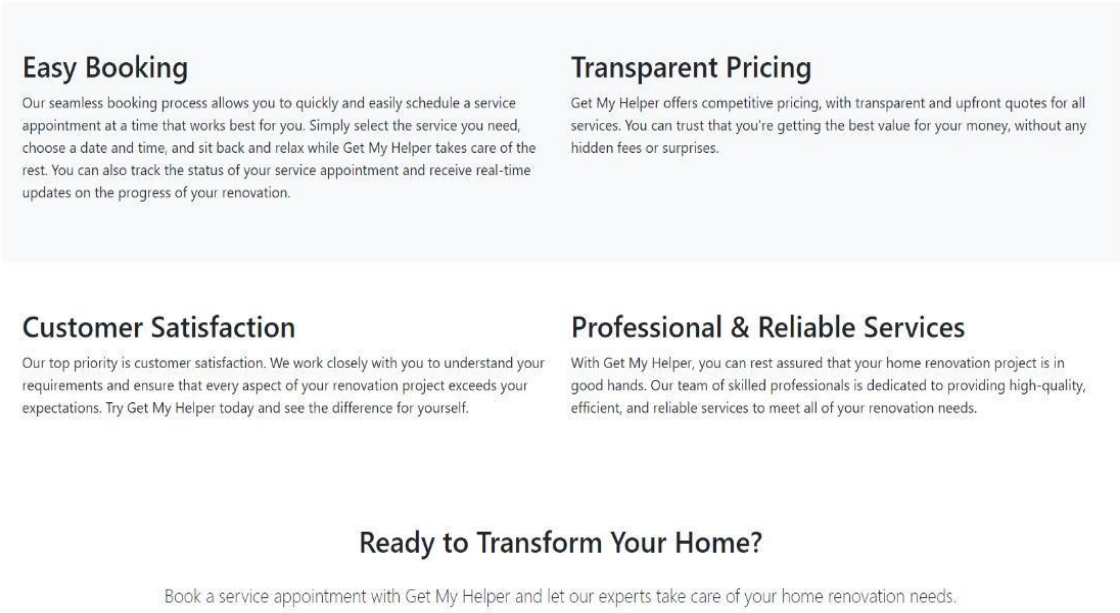

Fig. 8. Our features Page

5. Conclusions

The development and integration of a middleware website that bridges users with local helpers, bolstered by the integration of advanced AI and ML technologies, represent a pivotal step towards transforming the way individuals access services and leverage technology. Throughout this work, we've conscientiously navigated complex challenges, including safeguarding data privacy, ensuring algorithmic fairness, fostering user trust, achieving scalability, and adhering to ethical AI principles. By strategically implementing solutions such as robust data security measures, bias-mitigating algorithms, and transparent user feedback mechanisms, we've established a foundation of trust, efficiency, and user satisfaction. Looking forward, the work's envisioned expansion, both internationally and technologically, underscores our commitment to staying at the forefront of innovation. The pursuit of mobile app enhancements, AI-driven predictive analytics, immersive VR/AR experiences, and sustainable practices is poised to deliver an even more profound impact. Furthermore, our dedication to ethical AI practices will continue to underscore our commitment to user-centricity and responsible technological advancement. As we embark on this promising journey, we remain inspired by the potential to empower users, enable local helpers, and create vibrant, resilient communities. We are excited about the possibilities that lie ahead and the enduring impact this work will have in reshaping the dynamics of the gig economy and fostering collaboration within local communities on a global scale.[33] This high adoption rate underscores the importance of middleware in achieving seamless interoperability. Middleware can reduce the time required for system integration by up to 50%, as it provides standardized interfaces and protocols, eliminating the need for custom code to handle communications between different systems. Companies that deploy middleware solutions report an average improvement of 30-40% in resource utilization.[34] This includes better load balancing and more efficient use of server and network resources. Middleware can accelerate application development cycles by 25-35%, as developers can leverage pre-built middleware components to handle common tasks such as authentication, data exchange, and transaction management. Businesses can achieve cost savings of 20-30% in IT operations by using middleware. These savings come from reduced development costs, lower maintenance expenses, and improved efficiency in resource utilization. Companies typically see a positive ROI from their middleware investments within 12-18 months. The ROI is driven by increased operational efficiency, faster time-to-market for new applications, and reduced downtime. Middleware solutions enable horizontal scaling, allowing organizations to handle a 50-60% increase in workload without significant changes to the underlying infrastructure.[35]Middleware can improve system uptime by 99.95% through better fault tolerance and load balancing capabilities. This equates to only about 4.38 hours of downtime per year, significantly enhancing business continuity. Middleware can reduce the risk of data breaches by up to 40% by providing robust security features like encryption, authentication, and authorization. Middleware helps companies achieve regulatory compliance more easily, with over 90% of businesses using middleware reporting successful compliance with data protection regulations such as GDPR and HIPAA. The numerical data highlights the critical role of middleware in modern IT environments. From significant market growth and adoption rates to performance improvements and cost savings, middleware provides tangible benefits that enhance the efficiency, scalability, and security of business operations.

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Arrival Time Prediction for Transportation System

Advait Joshi [1], Dr Arati Deshpande [2] & Dr Emmanuel Mark [3]

[1]Student; SCTR's Pune Institute of Computer Technology, (Computer Engineering), Pune, Maharashtra, India, advaitkjoshi@gmail.com
[2]Associate Professor; SCTR's Pune Institute of Computer Technology, (Computer Engineering), Pune, Maharashtra, India, ardeshpande@pict.edu
[3]Professor; SCTR's Pune Institute of Computer Technology, (Information Technology), Pune, Maharashtra, India, emmanuelm@pict.edu

Abstract:

Public transport is a preferred mode of transport in cities. People use it to travel daily. The passengers are unaware of how much time they will require to complete the journey. Machine learning techniques can be used to predict the arrival time. This research paper showcases a comparative study of machine learning algorithms that can be applied for estimating the duration required for a mode of public transport to reach the destination. It will give the passenger an idea of the travel duration. In the proposed work, a total of 7 machine-learning regression algorithms are trained and compared. The model trained on the Ada Boost algorithm has an accuracy of 96.29%.

Keywords: Regression, Machine learning, Arrival time, transportation

1. Introduction

Public transport is a system of transportation which is a chargeable service for the use of the public. Public transport plays an important role in urban settlements. It aims to reduce traffic congestion, promote environmental sustainability, and enhance accessibility. Public transport includes buses, trains, metros, taxis, bike share, rickshaws, and a few other modes. Public transport is not only cost-effective but also beneficial to the environment. Many forms of public transport, such as electric buses and trains, contribute to reduced greenhouse gas emissions and air pollution when compared to individual car use, reducing the carbon footprint manifold. It is a boon for people who cannot drive as well as for elderly people.

Public transport in Pune city comprises PMPML (Pune Mahanagar Parivahan Mahamandal Ltd) bus, Metro Rail, suburban trains, auto-rickshaws, bike sharing and cabs. Since Metro Rail is limited to a few routes, the PMPML bus is the most used mode of public transport. The daily average ridership of PMPML is 12.41 lakh (till October) [14]. The PMPML has 467 bus routes and a total of 7687 bus stops [13]. This makes PMPML one of the densest public transport networks in Pune. On certain routes, the bus runs on a special lane; known as BRT - Bus Rapid Transit. This isolates the bus lane from the traffic on the road, reducing the impact of traffic congestion.

While public transport has many advantages, it comes with a few shortcomings. The time taken to reach the destination is not fixed. The person travelling on the bus has no clear idea how much time he/she might require to reach the destination. Our research reveals that the duration depends on the time at which the passenger boards the bus. We intend to provide software solutions to this problem using a machine-learning approach. This will provide an idea of duration to the passenger and thus he/she can precisely decide at what time it will be perfect to board the bus. This will have a direct impact on the lives of lakhs of citizens who travel by bus daily. It will ultimately strengthen peoples' confidence in public transport, thus leading to an increased preference to travel by bus. When more and more citizens start preferring public transport over personal vehicles, it will directly lead to reduced traffic on roads as well as have a positive environmental impact. Our research will enhance peoples' trust in public transport and ultimately lead to a

rise in the number of people choosing public transport over a personal vehicle, hence reducing traffic congestion, and controlling emissions of greenhouse gases.

2. Literature Survey

Researchers have proposed their algorithms for arrival time prediction of three different modes of transport: Road, air, and water. The previous work can be classified based on whether the existing system uses real-time location data or is trained on historical data.

2.1 Mode of transport: Road

2.1.1 Using real-time location tracking

In [2], the study explores the traffic congestion state by leveraging the ETA from the Google Maps API, combined with factors such as weather and traffic conditions. The classification process categorizes traffic into five distinct stages, ranging from smooth flow to heavy congestion. Among the methods evaluated, the Random Forest classifier achieved the highest accuracy at 92%. Similarly, [7] presents a Real-Time Locating System that integrates Global Positioning System (GPS) and Global System for Mobile Communications (GSM) wireless technologies. The study compares predicted arrival times with actual times, providing insights into the model's accuracy.

Building upon the approach in [7], [12] focuses on a model developed using automatic vehicle location data, applied to a bus route in Texas. This study contrasts models based on historical data with deep learning-based models. Notably, instead of using an ensemble method as in [7], the researchers proposed an Artificial Neural Network (ANN) model, which yielded the highest accuracy among the tested methods. [10] introduces an ETA model specifically designed for school buses in Canada. This model incorporates data from both previous and current days, applying an operational strategy to minimize risks associated with overestimation. The model relies on a GPS-based automatic vehicle location system for real-time bus tracking and demonstrates lower prediction error levels compared to moving averages and regression methods.

LSTMs are used for the estimation of arrival time in [16]. The regularity patterns in the dataset are captured using LSTM. They have used the online learning method to keep on updating the model based on collected real-time data. Based on the conducted experiments, they have concluded that the LSTM model outperforms the SVR model.

2.1.2 Using historical data

In [1], the authors propose a classification model to replace the more traditional regression models typically used in estimating time of arrival (ETA). This approach addresses the challenge of unknown trajectories in future trips by introducing a novel Categorical Approximate Method to Estimate the Time of Arrival. The classification labels correspond to the average time of each category, with travel time approximated using the weighted average of different classes. This new method is touted for its superior performance and reduced computational power requirements. Similarly, in [11], a Support Vector Machine (SVM) neural network algorithm is utilized to train the model and forecast arrival times. The study introduces a segment-based model that predicts travel time for the subsequent segment based on the current segment's time.

Random Forest, a widely recognized algorithm in prediction models, is the focus of [4], where different variable selection methods are compared. The comparison is based on computation time, the number of variables, and the area under the receiver operating characteristic curve, providing valuable insights into the efficiency of these methods. [9] presents a model designed to predict the arrival of a bus at the same stop across different routes. The study employs a deep learning approach alongside machine learning algorithms like SVM and linear regression, with results indicating that SVM outperforms the other three models.

A novel approach is used in [15], by proposing a hybrid model. The model uses a kNN classification algorithm for pattern matching. Further, they have used the Kalman filtering technique. They have used time-series analysis. Their model depends highly on the latest entry in the time-series data. Alternatively, they have proposed exponential smoothening to omit the requirement of keeping a record of historical data.

Table 1 shows the comparative statistics of accuracy of models tested in [2], [9] and [12]

Table 1 Comparison of models tested on the transportation system by road

Reference	Model	Average accuracy
[2]	Random forest	92%
[9]	Support vector machine	93.32%
[9]	ANN	91.32%
[9]	kNN	90.73%
[9]	Linear regression	91.21%
[12]	Historical data based models	92.59%
[12]	Regression models	85.43%
[12]	ANN	96.25%

2.2 Mode of transport: Air

In [5], the focus is on predicting the estimated time of arrival (ETA) for commercial flights, with factors such as weather conditions, air traffic, and potential flight paths playing a crucial role. The study compares different models, analyzing trajectory data, meteorology data, airport data, and airspace data to identify the most accurate model. Adaptive Boosting (AdaBoost) and Gradient Boosting are applied, and the results are compared, with the researchers reporting a root mean square error (RMSE) of 4 minutes. Similarly, [8] presents a model developed for flight ETA prediction, which accounts for the statistical relationships between flight parameters, air traffic, and weather information. The model implements a Random Forest classification algorithm, observing the out-of-bag RMSE as the number of grown trees increases. Feature importance is also analyzed, revealing that the destination airport is the most significant factor among those considered.

A new approach is proposed in [3] for predicting the ETA of flights at the runway upon entering the Terminal Manoeuvring Area. The study compares the performance of various machine learning algorithms, including neural networks and ensemble methods. The authors demonstrate that their proposed stacked model outperforms individual models in terms of accuracy and stability.

2.3 Model of transport: Water

In [6], a model is proposed which makes use of an Automatic Identification System and Long-Range Identification and Tracking on ships. This historical data is rasterized. A pathfinding algorithm is developed based on which the ETA predictions are made.

3. Methodology

Estimated Time of Arrival (ETA) is an important aspect of transportation. A person who is travelling should have a clear idea about how much time will be required to reach the desired destination. As discussed in the related work, research has been done previously to accurately predict the ETA. Some of the methods demand real-time vehicle tracking. However, real-time Global Positioning System (GPS) data processing demands high computation power. Also, it demands GPS hardware to be installed in the target mode of transport, in this case, the bus. To avoid the use of demanding resources like GPS, historical data was chosen by us. Models based on historical data demand significantly less computation power to train. Also, no hardware is to be installed for it. The following methods have been used as a part of model implementation:

1. **Data collection**: The data on the time at which the bus started from the source and the number of minutes required to reach the destination was collected manually by travelling on bus number 103 of PMPML. The data includes the timestamp of boarding the bus and the duration of the journey in minutes. The bus runs on a busy route in Pune city: from Kothrud Depot to Katraj. There are a total of 35 stops on the 13 km-long route. A dataset of 100 samples has been collected for the journey from the Vanaz Metro Station stop to the Bharati Vidyapeeth Gate stop.

2. **Data pre-processing**: Due to exceptional conditions like diversion of the route due to excavation on the road, the duration showed an anomaly as compared to normal circumstances. Such anomalous data points were detected and removed after studying the plot of board time v/s duration.

3. **Splitting the data**: Split the data, 80% for training the model and 20% for testing using the scikit-learn library in Python.

4. **Model training**: Trained a model on 7 different algorithms as mentioned in Table 1. Performed hyperparameter tuning on the models using grid search.

5. **Model evaluation**: Evaluated the 7 models by calculating the Mean Squared Error (MSE), R2 Score and Mean Absolute Percentage Error (MAPE).

The flow of data is explained in the architecture diagram in Figure 1. The data is processed by removing anomalous values of duration due to exceptional circumstances, like a breakdown. The pre-processed data is used to train a supervised machine learning model. Three different models are trained on the same data to analyse which one fits the best. Hence, it is trained on linear regression, decision tree and random forest. The user inputs the time at which he is planning to board the bus. The server passes a query to the trained model. The model computes the predicted value of travel duration and returns it to the user.

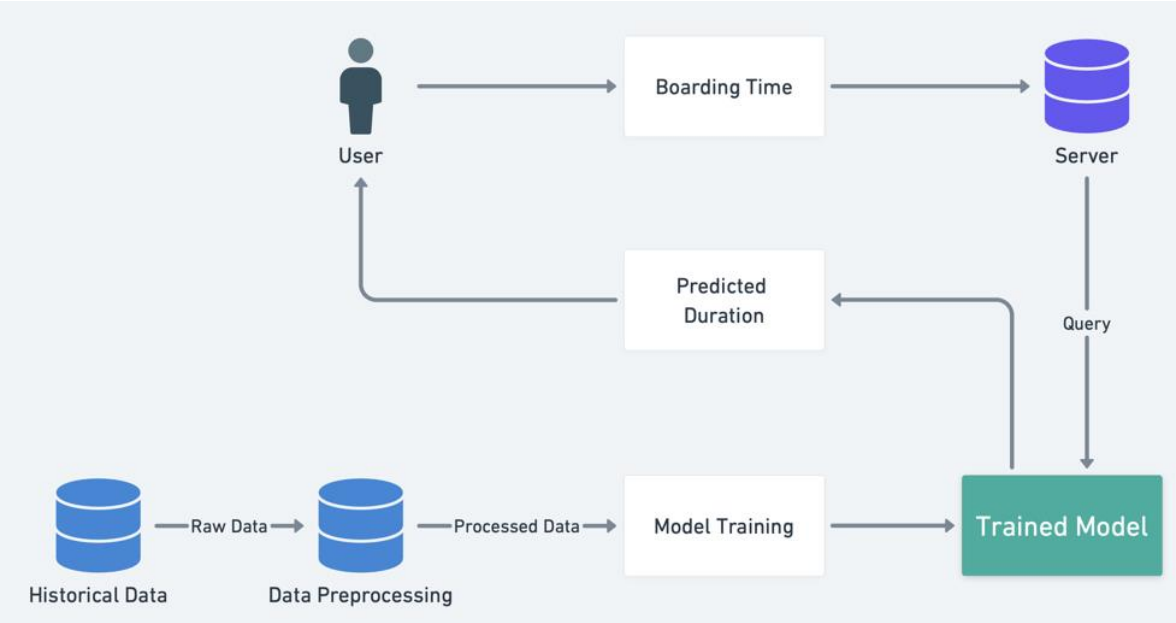

Fig. 1 Proposed Architecture

4. Results and Discussion

Table 2 shows the MSE, R2 Score and MAPE of all the 7 models.

Table 2 MSE, R2 Score and MAPE of each model

Model	Mean Squared Error	R2 Score	Mean Absolute Percentage Error
Linear Regression	15.8983903205065	0.295145256726312	0.06661971352684455
Support Vector Machine	13.4476553696827	0.403798530408155	0.06069024294442641
Decision Tree	11.4521604938272	0.492268746579091	0.05112715444818341
Random Forest	10.1000867198518	0.552212904045978	0.04580188384897036
Gradient Boost	10.1000867198518	0.527455189864827	0.04763390542108543
Ada Boost	5.072266003921091	0.8135238641472332	0.03712201500446292
K Nearest Neighbours	10.3666666666667	0.540394088669951	0.04900689887222298

Table 3 shows the values of optimal hyperparameters of the Ada Boost model.

Table 3 Hyperparameters of the AdaBoost model

Hyperparameter	**Value**
Number of estimators	10
Learning rate	0.01
Loss	Squared error

The following are the key observations:

- Linear regression does not perform well in this case. The reason is the non-linear relationship between the time stamp and the duration. In the early morning, there is less traffic on roads, so travel time is lower than average. During office hours i.e., 8 A.M. to 10 P.M. travel time is high due to peak in traffic. During noon, there is again a drop in traffic, hence leading to a reduction in travel time. It rises again in the evening i.e., 5 PM and onwards which is a usual time for people travelling from office to home.

- The Ada Boost model performs the best with an accuracy of 96.29%. It has the least MSE and MAPE among all the models.

- We observed that the model shows slightly greater deviations from the predicted value on Thursdays and Sundays; since Sunday is a holiday, there is an irregular trend in traffic patterns. Thursday is an industrial holiday, so on Thursdays, less time is required than any other day.

Figure 2 and Figure 3 show the comparison between the R2 Score and MAPE respectively of the 7 models.

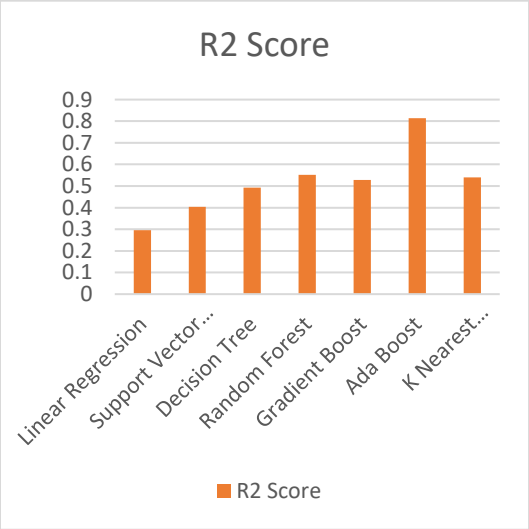

Fig. 2 Comparison of R2 Score

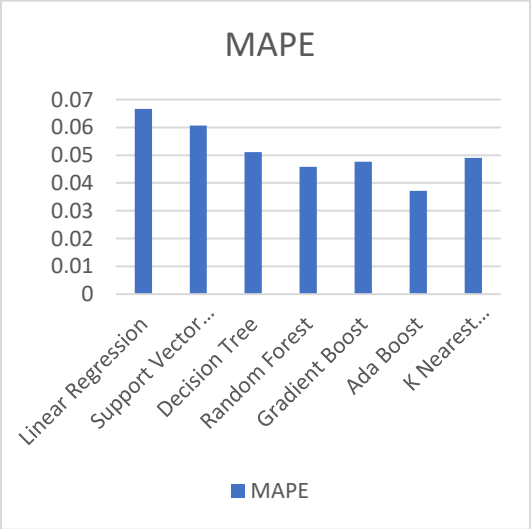

Fig. 3 Comparison of MAPE

5. Conclusion

The primary objective of this study is to comprehend the prediction of arrival time in public transport systems. Machine learning techniques prove to help predict the arrival time based on at what time the passenger has boarded the bus. Our research has demonstrated how supervised learning can predict arrival time by learning the trend and relations between the boarding time and duration required to reach the destination. Out of all the models we trained on the data, the model trained on the Ada Boost algorithm has shown a maximum R2 score of 0.8135 and an accuracy of 96.29%. This methodology can be applied to scale the model further on different routes of public transport, which might be a time-consuming process as it demands manually noting down the time stamp and duration. We can get help from people who travel daily on the same route. In the future, we plan on expanding parameters by considering the day of the week, and weather conditions, and checking for diversions on the route to further enhance predictions.

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Investigative Study of Data Tiering Systems and Supports

Gargi Mhaskar [1], Soham Kulkarni [2], Mokshad Vaidya [3], Vaibhav Mahajan [4] & Dr. Shweta Dharmadhikari [5]

[1]Gargi Mhaskar; PICT (Information Technology), Pune, Maharashtra, India, mhaskargargi268@gmail.com
[2]Soham Kulkarni; PICT (Information Technology), Pune, Maharashtra, India, sohamkulkarni0706@gmail.com
[3]Mokshad Vaidya; PICT (Information Technology), Pune, Maharashtra, India, mokshad.nv0709@gmail.com
[4]Vaibhav Mahajan; PICT (Information Technology), Pune, Maharashtra, India, nvaibhavmahajan00@gmail.com
[5]Dr. Shweta Dharmadhikari; PICT (Information Technology), Pune, Maharashtra, India, scdharmadhikari@pict.edu

Abstract:

Data storage and management in modern computing environments pose significant challenges, with a growing need for efficient and cost-effective solutions. Data tiering is a crucial aspect of modern storage systems, enabling efficient management and optimization of data placement across different storage tiers based on various criteria such as access frequency, performance requirements, and cost considerations. This paper provides a comprehensive study of data tiering approaches, methodologies, and implementations across a variety of systems.

Keywords: Data Tiering, Storage Management, Cold Data, File System

1. Introduction

In today's age of data, it has become crucial to optimize the storage of that data to reduce cost and latency while improving throughput, reliability, and availability. One of the strategies for storage optimization is data tiering. It is a data storage strategy that defines different storage ties and shifts data between tiers to fulfil the requirements of an organization depending on the usage. Cloud tiering involves storing frequently accessed data in fast cloud storage while less used data is assigned to slower and cheaper storage. Advantages of cloud tiering also include more granular control over cloud resources and rapid data recovery in case of emergencies such as natural disasters or sudden system failure. Extending this need for storage optimization to the file system present on compute clusters and on-premise servers, we can utilize the primary, more expensive storage more judiciously by shifting a bulk of the data to secondary storage services such as AWS S3 and Google Cloud Storage, which implement a Pay-As-You-Go model with high durability. Certain factors need to be considered while implementing data tiering. These factors are as follows:

- *Block-Level vs File-Level Tiering*: File-level tiering operates at a higher granularity, allowing for more precise control over which files are moved to lower-cost storage tiers based on their access patterns and importance. This approach maximizes savings without locking organizations into specific storage vendors or technologies. In contrast, block-level tiering works at a lower level, moving data in fixed-size blocks between tiers based on usage patterns. While block-level tiering offers benefits like faster data retrieval, file-level tiering provides more flexibility and cost-efficiency, especially in heterogeneous environments or those leveraging both on-premises and cloud storage. [11]
- *Identification of Cold Data*: Identifying cold blocks accurately is a crucial task when we are implementing cloud tiering. Cold blocks can be identified using algorithms such as Least Recently Used (LRU) and AI-based Ensemble Models that consider factors like access frequency, file size and user information. The analysis of metadata can be leveraged for cold data identification by considering both access frequency and recency.
- *Primary Storage Utilization*: It is important to note that data tiering has been developed to allow for more judicious use of the primary storage without losing data. While data tiering prevents the primary storage from being over utilized, we have to prevent it from being under- utilized. Some methods of ensuring this are designating a maximum limit of utilization of the primary storage beyond which cold data is tiered, or defining a hot-cold storage splitting ratio. [2]
- *Secondary Tier Read Write Costs*: The costs associated with reading data from and writing data to the

secondary tier need to be considered while implementing data tiering. A policy needs to be defined for data currently stored in the secondary tier that is accessed frequently, and, therefore, can no longer be considered as cold data, to be migrated back to the primary tier. File access patterns of the cloud tier need to be monitored to judge which data needs to be written back to the primary tier. The present utilization of the primary tier should also be considered, along with migration cost and secondary tier read cost trade off.

Careful consideration of the above factors allows for the construction of data tiering supports that are best suited to the requirements of any particular organization. A major challenge in this field is, therefore, selecting the right parameters as making the wrong choices can lead to increased read-write costs because of selecting the wrong data to be tiered or underutilization of the primary tier. The objective of this paper is to study various data tiering supports and their methodology.

2. Literature Survey

This section presents an understanding of the different methodologies used by various data tiering supports.

2.1 Automated Cloud Storage Tiering through Hot-Cold Data Classification [1]

The proposed automated storage tiering (AST) system in [1] aims to predict data temperature (frequency of access) and automate data migration between hot and cold storage tiers in cloud environments. The system leverages machine learning techniques, including stacked ensemble learning, to categorize data and allocate it to the appropriate storage tier without manual intervention.

1) Data Temperature Prediction: The system learns from past data access patterns and user behaviors to predict the future access frequency of files. This prediction engine utilizes various input features such as file access frequency, size, type, user information, etc. Deep neural networks (DNN), support vector machines (SVM), and ensemble learning methods are all used as prediction models.
2) Automated Data Migration: Based on the predicted data temperature, files are automatically allocated to either hot or cold storage. The system operates on scheduled routines (e.g., weekly, biweekly, monthly) to perform data migration tasks. New files are initially stored in a reserved hot space until the next scheduled operation.
3) Components of the System:
   - Data Content Manager: Collects access logs, monitors storage usage, and generates metadata for input datasets.
   - Hot-Cold Data Prediction Engine: Utilizes super- vised learning methods and ensemble learning to predict future file access patterns and determine data temperature.
   - Flexible Output: Generates a file priority list based on predicted data temperature, allowing customizable hot-cold storage splitting ratios.
4) Evaluation and Testing: Evaluation of the system is done by considering Feasibility, Reliability, and QoE. The cost savings, quality of experience (QoE), correctness of hot data predictions, and flexibility with different cloud storage providers' business strategies are measured and considered during the testing and evaluation.

2.2 FabricPool: A NetApp® ONTAP® software component [2]

FabricPool is a feature in ONTAP that enables tiering of data between a local tier (storage aggregate) and a cloud tier (external object store), optimizing storage efficiency and performance. ONTAP is a proprietary operating system used in storage disk arrays.

1) Block Temperature: Blocks are assigned temperature values indicating their activity level. Hot blocks are stored in the local tier, while cold blocks are moved to the cloud tier based on a cooling scan.
2) Object Creation: Blocks are grouped into 4MB objects before being written to the cloud tier. Each object contains 1,024 4KB blocks.
3) Data Movement:

a. Tiering to Object Store: Cold blocks are identified, grouped into objects, and then moved to the cloud tier in accordance with volume tiering policies. Tiering to the cloud tier is only enabled by default if the local tier is more than 50% full, to prevent underutilization of the local tier.

b. Reading from Object Store: When data is read from the cloud tier, concurrent byte-ranged GET operations are initiated, optimizing network efficiency. Only the necessary Write-Anywhere-Fall- Layout (WAFL) are read.

4) Random Reads: Cold blocks read randomly from the cloud tier are made hot and written back to the local tier for improved performance.
5) Sequential Reads: Sequential read-ahead requests are made to the cloud tier to optimize performance, but the data remains in the cloud tier.
6) Write-Back Prevention: When the local tier is over 90% full, or in other words, it is heavily utilized, cold data is read directly from the cloud tier rather than being written back to maintain local tier performance.
7) Object Deletion and Defragmentation: FabricPool deletes entire objects based on the percentage of un-referenced blocks within an object.

2.3 Auto-Tiering System using Deep Reinforcement Learning [3]

This method leverages DRL to optimize storage costs while maintaining performance requirements. The challenge faced by cloud storage providers is in efficiently managing data across two tiers of storage: high- performance, high-cost storage and low-performance, low-cost storage. The goal is to minimize storage costs while ensuring that performance requirements are met for different data access patterns.

1) Auto-Tiering System: An auto- tiering system is pro- posed that dynamically classifies data into different storage tiers based on its access patterns and cost considerations. By automatically placing data in the appropriate tier, RLTiering aims to optimize storage costs while maintaining performance.
2) Deep Reinforcement Learning (DRL): DRL techniques are used to train an agent to make tiering decisions. DRL allows the agent to learn optimal tiering policies through trial and error, maximizing long-term rewards (cost reduction) over time.
3) State Representation: The state of the storage environment is represented by various factors, including data access frequency, data size, storage costs, and performance metrics.
4) Action Selection: The DRL agent selects actions corresponding to tiering decisions, such as promoting data to a higher-performance tier or demoting data to a lower-cost tier. The actions are chosen to maximize the expected cumulative rewards over time, balancing cost savings with performance requirements.
5) Reward Mechanism: A reward function is defined to incentivize cost reduction while maintaining performance. The agent receives rewards based on how well its tiering decisions align with cost-saving objectives. For example, the agent may receive higher rewards for demoting infrequently accessed data to a lower-cost tier.

2.4 Cloud Tiering for Layered Tiers [4]

[4] focuses on optimizing storage tiers for cost- effective data storage by proposing a rule-based classification approach. This approach considers four storage tiers instead of two, aiming to improve performance, efficiency, and cost savings.

1) Rule-Based Classification: The classification scheme utilizes IF-THEN rules for predicting the storage tier for each object based on specific criteria such as access frequency, data size, and age of the stored object. Rules are defined to assign objects to different storage tiers based on their characteristics.
2) Classification Criteria: Four general tiers are defined: Premium, Hot, Cold, and Archive.

a. Premium tier: For continuously or near-continuously accessed data requiring high performance and durability.

b. Hot tier: For data with frequent access patterns, accessed daily or weekly, requiring fast access times.

c. Cold tier: For data with infrequent or irregular access patterns, accessed monthly or quarterly.

d. Archive tier: For rarely accessed data with minimal retrieval requirements, used for long-term storage and compliance.

3) Solution Approach: Weights (W) are defined for factors such as size (Z), access frequency (F), and age (A) of the data. The data is represented as a list of dictionaries. Each dictionary contains size, access frequency, and age of an object. The priority score for each object is calculated using defined weightings for size, access frequency, and age. Objects are, then, divided into groups based on priority score thresholds for each storage tier. Priority score thresholds are set for each tier to balance trade-offs between data size, access frequency, and age. These P The thresholds are as follows:

a. Premium: Priority score threshold of 1.0 for critical and frequently accessed data.

b. Hot: Priority score threshold of 0.7 for data with slightly lower priority but significant access requirements.

c. Cold: Priority score threshold of 0.4 for less frequently accessed data, offering cost-effective storage.

d. Archive: Priority score threshold of 0.1 for rarely accessed data, serving as a long-term storage solution with cost optimization.

4) Window Definitions for Access Frequency: Nineteen possible windows are defined ranging from hourly to yearly to capture different access frequency patterns.

2.5 Middleware enabling Multi-Tiered Cloud Storage Instances [5]

The middleware proposed in [5], named Tiera, aims to address the complexity introduced by multi- tiered cloud storage services by providing a middleware solution encompassing numerous cloud storage providers and enables the simple setting of data storage policies to accomplish required trade-offs. Tiera instances encapsulate multiple cloud storage services and allow for easy specification of storage policies. Clients of Tiera instances are shielded from the under- lying complexity of multi-tiered cloud storage services. Tiera supports dynamic replacement/addition of storage policies and tiers. The architecture is as follows:

1) Data Model: Tiera uses an object storage model so that data is managed as objects, enabling unified access to data distributed among different storage services. Objects are treated as uninterpreted sequences of bytes with common attributes such as size, access frequency, dirty flag, location, and time of last access.

2) Architecture Overview: Tiera instances are composed of three layers: the application interface layer, the storage interface layer, and the control layer. The application interface layer provides a simple PUT/GET API for storing and retrieving data. All of the varied storage services encompassed by the Tiera instance interact with the storage interface layer. The control layer manages data placement and movement across tiers based on event-response mechanisms.

3) Event-Response Mechanism: Tiera supports three types of events: timer events, threshold events, and action events. Responses to events include storing, retrieving, moving, copying, compressing, encrypting, decrypting, and deleting data. Responses can be combined and customized to define data management policies easily.

2.6 Hybrid Cloud Storage Architecture [6]

The method proposed in [6], entitled CloudMW, utilizes a combination of S3, EBS, and EC2 local storage to support efficient data management in cloud environments. The architecture consists of two main layers: cloud management and storage management middleware.

1) Cloud Management Layer: By means of service-provider-defined APIs, this layer is in charge of data storage and data services delivery. It manages the consistency of data transfers between S3 and EBS as well as operations like backup, restoration, deduplication, and encryption and decryption. Working data sets are primarily stored on EBS volumes but backed up to S3 for dependability and archival purposes.

2) Storage Management Middleware: This layer is responsible for data services for client virtual machines (VMs) and facilitates data sharing among multiple VM clients accessing shared data on EBS volumes. It incorporates various mechanisms to enhance performance and efficiency, including Data Chunking (files are partitioned into chunks and distributed across storage nodes for parallel access, improving data transfer bandwidth), Data Replication, Storage Virtualization (cloud storage space is virtualized and can be accessed as a single storage device). Some crucial mechanisms also include:
   - Multi-level Caching: Different tiers of storage are utilized, with S3 serving as the back-end long-term storage, EBS volumes providing online storage services, and EC2 instances offering direct-attached storage. Caching technology is employed to optimize data access performance.
   - I/O Scheduler: It handles issues such as changeability in I/O sizes, locality of accesses across VMs, and different request priorities based on application requirements.
   - Metadata Management: Manages metadata information using SOAP/REST protocols. It generates small- sized indirection maps to convert file system block addresses to the present locations of blocks on cloud storage and EC2's local storage.

2.7 Automated Data Tiering in a Centralized Storage System for Private Cloud Environments [7]

The storage system implements automated data tiering to efficiently manage user files based on access patterns and performance requirements. The automated data tiering methodology efficiently manages file storage by dynamically migrating data between high-speed SSD drives and high capacity, lower cost SAS drives based on access frequency, optimizing performance and cost-effectiveness.

1) System Overview: The storage system consists of three pairs of duplicated storage array controllers connected to disk chassis with a total capacity exceeding 3 PB. Near- line SAS disk drives are used for bulk storage, while 24-TB solid-state disk (SSD) drives provide high- speed access. Five pairs of duplicated NAS heads are included for load balancing, connected to all disk array controllers via duplicated Fiber channel switches.
2) Automated Data Tiering: The array controller features automated data tiering, allowing users to write files to the fastest disk drives (Tier 1). The frequency of access to each block is calculated, and blocks not accessed for over two weeks are migrated to slower disk drives (Tier 2). Conversely, regularly accessed blocks are migrated from Tier 2 to Tier 1. The migration process occurs nightly to optimize file access speed and reduce costs associated with high-speed disk drives.
3) Types of Services: Two types of storage services are provided: high-speed and archive. High-speed access is required for high-speed services, utilizing SSD drives (Tier 1), while archive volumes are configured only on Tier 2 (hard disk drives). A migration mechanism between RAID1 and RAID5/6 is implemented, with RAID1 providing faster access but requiring more space, and RAID5/6 effectively utilizing allocated space but with slower access. Users can initially write archiving files on RAID1 blocks, which then migrate to RAID5/6 blocks after a few weeks.

2.8 Adaptive Fine-grained Cache Management for SSD-based File Systems [8]

The adaptive fine-grained cache management scheme aims to improve system performance and reduce write-back traffic to Solid State Drives (SSD) in a cloud storage environment.

1) Adaptive Fine-grained Cache Management (AFCM) dynamically selects cache modes based on a page's "dirty ratio." The dirty ratio represents the proportion of modified data within a page compared to its total size.
2) AFCM employs a Cost-Benefit Model to determine the most suitable cache mode for each synchronized page.
3) There are two cache modes: Coarse-Grained Cache Mode and Fine-Grained Cache Mode.
   a. Coarse-Grained Cache Mode: It involves caching entire data pages at once. It requires less overhead for indexing and management, and provides lower granularity, meaning that a larger portion of data is cached together. However, it results in lower cache utilization.

b. Fine-Grained Cache Mode: It involves caching smaller units of data, such as individual cache lines or smaller segments. It requires higher overhead for indexing and management due to the finer granularity. The higher granularity allows for more precise caching of modified data. However, it has higher overhead.

4) The benefits of AFCM include reduced SSD write operations, while the costs encompass metadata overhead. If benefits outweigh costs (indicating a high dirty ratio), AFCM selects fine-grained cache mode to optimize synchronization efficiency. If costs outweigh benefits (indicating a low dirty ratio), AFCM opts for coarse- grained cache mode to minimize metadata overhead.

5) AFCM dynamically adjusts cache modes as the dirty ratio fluctuates, ensuring efficient cache management in response to workload changes.

2.9 Tiered File System for Persistent Memories and Disks [9]

In [9], the authors have proposed TPFS. It is a tiered file system spanning disks and persistent memory (PM), that leverages and PM and disks to offer high file performance for various access patterns. TPFS is implemented based on NOVA. NOVA is a PM-based kernel-space file system which maximizes performance on hybrid memory systems and provides robust consistency guarantees. TPFS inherits the design of log-structured file layout and scalable memory allocators from NOVA.

1) Sending I/O to the Most Suitable Tier: TPFS dynamically determines whether to send file writes and reads to PM or disks based on access patterns and workload characteristics. Small, synchronous writes are directed to PM for higher bandwidth and lower latency, while larger asynchronous writes are targeted to disks to leverage faster DRAM buffering. For reads, if DRAM bandwidth is underutilized, TPFS migrates read-hot data from PM to disk and caches it in DRAM for accelerated reads.
2) Accurate File Temperature Profiling: TPFS identifies the temperature of file blocks based on their access patterns and historical modification/read times. Write-cold files have older-than-average modification times and Read- hot files have newer-than-average read times.
3) High PM Space Utilization: TPFS optimally utilizes PM space by absorbing synchronous writes and using disks to expand capacity. It dynamically adjusts PM utilization thresholds based on application read-write patterns to efficiently handle file writes.
4) Exploiting DRAM Read Bandwidth: TPFS monitors read data flow from PM and DRAM, migrating read-hot data to disk and caching it in DRAM if DRAM bandwidth is underutilized. This approach maximizes read throughput by leveraging both volatile DRAM and non-volatile PM.
5) Migrating File Data in Groups: TPFS merges adjacent file data into big chunks for migration to disks, using sequential disk bandwidth to improve migration efficiency.
6) High Scalability: TPFS builds upon NOVA's per-CPU storage space allocators to comprise all storage tiers, improving overall scalability. It utilizes per-CPU migration and page cache writeback threads to improve the scalability of the tiered file system.

2.10 Utilization of Primary Storage of Compute Clusters as a Caching Tier [10]

The primary objective of this system is to enable VMware customers to leverage their vSphere clusters for application execution while utilizing secondary storage solutions for cost- effective data retention. This involves developing a caching hybrid storage system that integrates primary and secondary storage seamlessly. The methodology involves building upon VDFS (VMware Distributed File System), a hyper-converged distributed file system running on vSAN, to create caching- tier volumes. These volumes serve as the caching tier of the hybrid system, caching the working set of application data on primary storage while utilizing secondary storage for bulk data retention. The architecture is as follows:

1) VDFS Caching-Tier Volumes: These volumes cache the working set of application data on primary storage, hiding the latency of secondary storage. They utilize write- back cache on primary storage to optimize performance.
2) Caching Model: VDFS exposes cache-related properties to applications through extended attributes, enabling application-specific caching policies. For example, ap- plications can control caching behavior

based on the cached state of files, improving cache hit rates.

3) Caching at the FS Layer vs. App Layer: Caching functionality is exposed to applications at the file system layer, allowing different compute frameworks to manipulate caching state uniformly. This enables shared cache- related state across various applications, enhancing performance for the entire pipeline.
4) Write-Back Mechanism: Write-back of the cache follows a directed approach, giving applications fine-grained control over when updates are written back. This ensures continued operation even in the face of disconnection from the secondary storage.
5) Backends: The system supports various secondary storage backends such as Amazon S3 and remote file systems. Applications can seamlessly access these backends through VDFS caching-tier volumes, without needing to modify their operations.

3. Comparative Analysis

Ref No.	Title	Authors	Publication and Year	Type of Tiering	Methodology Used	Strengths	Weaknesses
1	A Novel Automated Cloud Storage Tiering System through Hot-Cold Data Classification (AST)	Y.-F. Hsu, R. Irie, S. Murata, and M. Matsuoka	IEEE 11th International Conference on Cloud Computing 2018	Cloud Tiering	Stacked ensemble learning for data temperature prediction. Data tiering happens automatically on scheduled routine basis such as weekly, monthly, etc.	Successful prediction of cold data leading to cost savings. System also ensures reliability, QOE, and flexibility	System has only been tested on non-commercial data. Training the ML model takes a long time.
2	FabricPool best practices, TR-4598 NetApp ONTAP 9.11.1	J. Lantz	NetApp Media 2024	Cloud Tiering	Enables automated data tiering at the block level using block temperature.	Has provisions to differentiate between over and under-utilized local storage, and random reads and sequential reads.	Specific only to NetApp's ONTAP system. Supports only block tiering.
3	RLTiering: Auto-Tiering System using Deep Reinforcement Learning	M. Liu, L. Pan and S. Liu	IEEE Transactions on Parallel and Distributed Systems Volume: 34, 01	Cloud Tiering	Dynamically classifies data into different storage tiers based on its access patterns and cost	Optimization because of deep reinforcement Has a Cost-driven approach without	May require significant computational resources for training

			February 2023		considerations using Deep Reinforcement Learning.	reduction in performance	
4	Towards Cloud Storage Tier Optimization with Rule-based Classification	A. Q. Khan, N. Nikolov, M. Matskin, R. Prodan, C. Bussler, D. Roman, A. Soylu	Lecture Notes in Computer Science, vol 14183. Springer, Cham 2023	Cloud Tiering	Cloud storage tier optimization using rule-based classification. Defines 4 tiers of Premium, Hot, Cold and Archive, and calculates weighted priority score for effective allocation of data.	Better differentiation between data due to consideration of 4 tiers. Assigns appropriate weights to all factors concerning data while calculating priority score.	May not be suitable for all types of data. Requires clear rule definitions.
5	Tiera: Towards Flexible Multi-Tiered Cloud Storage Instances	A. Raghavan, A. Chandra, and J. B. Weissman	Proceedings of the 15th International Middleware Conference December 2014	Multi-tiered Cloud Tiering	Middleware for easy specification of multi-tiered cloud storage instances and storage policies.	Provides easy specification of multi-tiered cloud storage. Enables rich array of storage policies.	May introduce additional complexities. Not yet compatible with horizontal scaling.
6	Optimizing storage performance in public cloud platforms	J. Wang, P. Varman, C. Xie	Journal of Zhejiang University SCIENCE December 2011	Multi-tiered Cloud Tiering	Hybrid cluster storage. Cloud management layer manages storing of data and provides data services. Middleware layer provides data services for client VMs and facilitates data sharing in shared data.	Decreases the possibility of performance variations and leads the way for realistic I/O QOS guarantees.	May not be applicable to private cloud environments.
7	A Centralized Storage System with Automated Data Tiering for Private	M. Shikida, H. Nakano, S. Kozaka, M. Mato, S. Uda	Proceedings of the 41st annual ACM SIGUCCS conference	SSD to SAS Drives Tiering	Automated data tiering that manages file storage by dynamically migrating	Provides high-speed and low-cost storage services at a low power	Specific to the authors' private cloud environment.

	Cloud Environment		on User services November 2013		data between high-speed SSD drives and high capacity, lower cost SAS drives based on access frequency.	consumption. Friendly interface for user.	
8	Efficient and Consistent NVMM Cache for SSD-based File System	Y. Chen, Y. Lu, P. Chen and J. Shu	IEEE Transactions on Computers, vol. 68, 1 Aug. 2019	Hybrid Cache based on DRAM and NVMM	AFCM that dynamically selects cache modes based on a page's "dirty ratio." Employs a Cost-Benefit Model to determine the most suitable cache mode	Significantly improves the system performance and reduces the write traffic to SSD compared to the conventional coarse grained cache management scheme.	Specific to SSD-based file systems
9	TPFS: A High Performance Tiered File System for Persistent Memories and Disks	S. Zheng, M. Hoseinzadeh, S. Swanson, and L. Huang	ACM Transactions on Storage, Volume 19 Issue 2, 6 March 2023	PM to SSD Drives Tiering	Dynamically determines whether to send file writes and reads to PM or disks based on access patterns and workload characteristics.	Bridges the gap between disk-based storage and PM-based storage. Provides high performance and large capacity to applications.	Specific to NOVA filesystem
10	Hybrid Cloud Storage: Bridging the Gap between Compute Clusters and Cloud Storage	A. Gupta, R. Spillane, W. Wang, M. Austruy, V. Fereydouny, and C. Karamanolis	ACM SIGOPS Operating Systems Review Volume 51 Issue 1, 2017	Cloud to Cache Tiering	Caching hybrid storage system built upon VDFS to create caching tier volumes, caching the working set of application data on primary storage while utilizing secondary	Data mostly resides on inexpensive cloud while compute runs faster primary vSAN storage enabling.	Specific to VMware's architecture.

					storage for bulk data retention.		

4. Proposed Methodology

We have developed a Proof-of-Concept specifically to implement block-level cloud tiering in XFS. The concepts involved in the POC are detailed below.

4.1 Introduction to XFS and Cold Block Identification

XFS is a high-performance 64-bit journaling file system renowned for its ability to efficiently handle large data volumes with minimal performance degradation, even under heavy loads. It supports variable block sizes, adjustable to system requirements, and excels in parallel I/O operations due to its allocation group design. Each allocation group, a subdivision of physical volumes, manages its own nodes and free space, facilitating concurrent processes and threads. As the primary local storage tier, XFS organizes files into blocks, which are fixed-sized data units. Block sizes in XFS can range from 512 bytes to 64 KB, depending on user needs and system commands. [12]

Considering that XFS files are organized as blocks, the blocks that are accessed infrequently i.e. cold blocks were identified using system commands that trace block-level operations. The system commands generate an output with multiple data points that have to be preprocessed to generate data points that can be utilized for cold-block identified. [13] In the methodology, the use of K-means clustering, a machine learning model, to generate a list of Hot and Cold blocks is proposed. The use of K-means is prompted by the dataset being unlabeled. Some of the features that are proposed to be used for training the model are Frequency, Recency and Mean Time Between Access.

4.2 Block Migration to Cloud Tier

Once the identification of the cold blocks is complete, the devised system has a four-step process to migrate the cold blocks to the cloud tier. The steps are detailed below

4.2.1 Mapping Block Numbers to Files

The system command used to deallocate blocks requires the input of file path and offset value. Hence, the cold block numbers identified need to be mapped to the respective file path and calculating the offset.

4.2.2 Storing Information of Cold Blocks

The identified cold block will soon be deallocated so it is essential that the primary tier has access to information about the deallocated block so as to perform read-write operations. The relevant data is stored in a table that is maintained on the local tier.

4.2.3 Uploading Cold Blocks to the Cloud and Deallocating space

Once the table is updated, the cold blocks are iteratively uploaded to the cloud tier. Simultaneously, every block that has been successfully uploaded to the cloud tier is immediately deallocated from the primary tier.

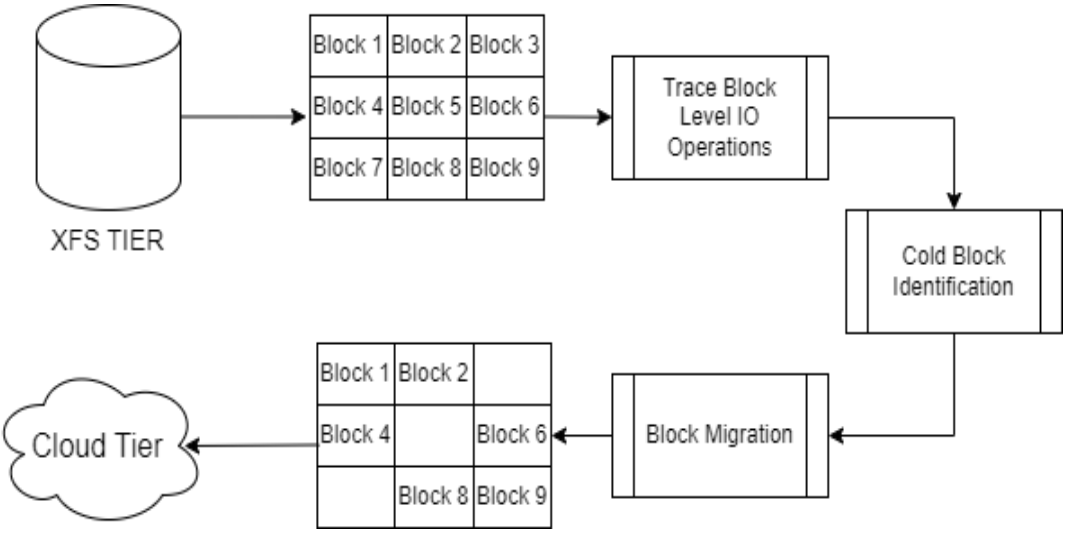

Fig. 1. Proposed System Architecture

4.3 Results and Discussion

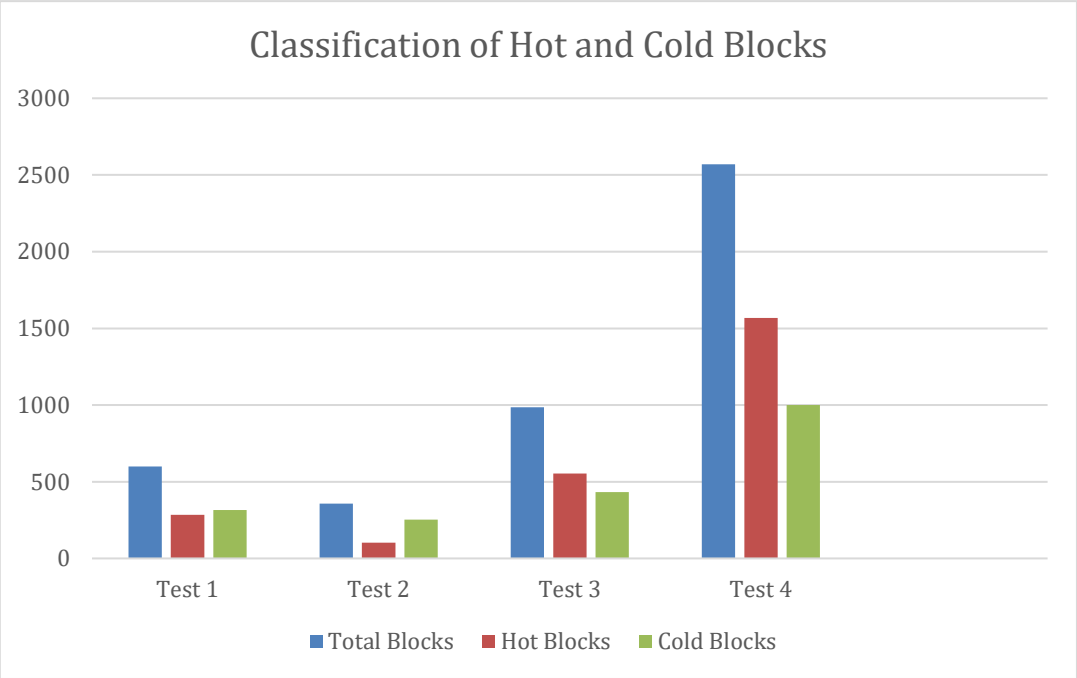

Fig. 2. Testing of Hot and Cold Block Classification

For evaluating the system, a dataset where blocks were randomly accessed to simulate the usage of an organization was generated. The data was preprocessed as described above and then K-means clustering was applied to generate two lists of Hot Blocks and Cold Blocks. As can be seen in the above graph, the percentage of cold blocks identified is dynamic. In the above graph, test 1 has 52.6% cold blocks, test 2 has 71.1% cold blocks, test 3 has 43.8% cold blocks, and test 4 has 38.9% of cold blocks. The system will then upload these blocks to the cloud tier, freeing up that space in the primary tier. By changing the number of clusters that the machine learning model is generating, the cloud tiering can be refined.

The system features a modular architecture allowing users to integrate various components, such as different log tracing methods, cold-block identification algorithms, or block migration commands, without affecting overall functionality. The solution presented is OS-agnostic and operates on any operating systems with XFS mounted,

requiring no additional infrastructure from Cloud Service Providers. The system proves that block-level tiering can be efficiently implemented on XFS, providing a cost-effective method for handling big data.

While current data tiering strategies address various scenarios, the proposed system specifically applies cloud tiering to XFS, making it highly effective for organizations managing large volumes of data. The proposed system's current limitations include the lack of testing on a dataset that accurately reflects an organization's usage patterns, which hinders the ability to assess the model's accuracy and develop a more precise model. Future improvements include generating a genuine dataset for better precision, enhancing user control, adding more cloud tiers for nuanced data usage patterns [14], and refining algorithms to optimize local tier utilization.

5. Conclusion

This paper extensively explored various data tiering systems, encompassing tiering between local storage and the cloud, multi-tiered cloud storage, and SSD-based file systems. Each system employs diverse approaches to identify data for migration across tiers. Additionally, these systems carefully weigh the costs and benefits to determine their effectiveness in optimizing storage. Looking ahead, there's ample room for advancement in data tiering methodologies.

The paper also elaborates on the proposed methodology for cloud tiering in XFS includes tracing system block operations, identifying cold blocks, and managing block migration to the cloud. The modular design allows customization without disrupting the overall system. Using K-means clustering (k=2) for cold block identification, the system classifies 38-70% of blocks as cold. However, the value of k can be changed according the number of tiers available for more nuanced cloud tiering. Further, the system can be modified to prevent underutilization of the primary tier. Future improvements in the system could include ensemble classification models, tiering based on primary storage utilization and, extensive testing on actual organizational data to improve the model.

Data Tiering and Cloud Tiering, in particular represent an important aspect of optimized storage management that could lead to significant cost reductions for every data-heavy organization. Further research in this field should focus on file system-specific tiering that incorporates both access frequency and recency for enhanced optimization.

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Identification of Melanoma Skin Cancer Through Image Processing and DL

Atharva Kulkarni [1], Siddhesh Jadhav [2], Siddhesh Kulkarni [3], Tejas Lokhande [4] & Mr Pravin S. Game [5]

[1]Student; SCTR's Pune Institute of Computer Technology, (Department of Computer Engineering), Pune, Maharashtra, India, atharvk2109@gmail.com
[2]Student, SCTR's Pune Institute of Computer Technology,(Department of Computer Engineering), Pune, Maharashtra, India, siddheshjadhav7136@gmail.com
[3]Student, SCTR's Pune Institute of Computer Technology, (Department of Computer Engineering), Pune, Maharashtra, India, kulkarnisiddhesh29@gmail.com
[4]Student, SCTR's Pune Institute of Computer Technology, (Department of Computer Engineering), Pune, Maharashtra, India, tejaslokhande92@gmail.com
[5]Associate Professor; Pimpri Chinchwad College of Engineering & Research (PCCOER), (Department of Computer Engineering), Pune, Maharashtra, India, pravinsgame@gmail.com

Abstract

Melanoma is still the most deadly type of skin cancer among those that typically develop. Like other cancers, this one has a higher probability of survival if it is discovered early. Medical professionals find that computer-aided diagnostics is helpful in the detection of melanoma. In recent times, image processing, deep learning, and machine learning have emerged as the top options. The ABCDE rule is used to identify melanoma in most situations. Thus, the same technique is applied. The collected photographs or images from the database are transferred to the server via a local application. Features are extracted and segments are done using different image processing techniques. AlexNet, ResNet50 and EfficientNetB7 learning techniques. Various classifiers provide their outputs. The primary goal of this study is to compare the accuracy of different classifiers and use REST API to transmit the results to a local application. The study will be carried out using ISIC 2016 benchmark dataset.

Keywords-: Melanoma, Image Processing, Deep Learning, Machine Learning, CNN, AlexNet, Resnet50, EfficientNetB7

1.1 Introduction

Being the biggest organ in the body, the skin serves as the body's first line of protection. It has the functions of protecting, secreting, excreting and regulating body temperature. With the changes in lifestyle and environment, various skin diseases affect the normal life of human beings. There are more incidences of skin cancer than any other type of cancer, and skin illnesses affect a large number of individuals worldwide. As per [16], in the United States alone, there were 5.4 million new instances of skin cancer each year. As per [17], Melanoma accounts for only 5% of all skin cancer diagnoses, but 75% of those cases have the potential to be fatal. The factors for melanoma development are primarily UV radiation, which occurs in solar radiation. Other factors are signs on the skin or genetics. There is a good survival percentage for melanoma if it is identified early and treated appropriately. The prognosis for advanced melanoma remains poor. However, if detected during the earliest stages, the curative effect and prognosis are better.
Accurate screening for early identification of melanoma is a critical first step in lowering mortality and prolongation of patients' survival. In recent years, dermatologists around the world have devoted considerable attention to the study of dermoscopy. For accurate detection of melanoma, dermatologists use biopsy, which means the tissue or cells removal for analysis which is usually associated with pain, time and cost.
Dermoscopy is a non-invasive method of skin imaging that provides a bright, enlarged image of a specific area of skin

to help make skin spots easier to see. Dermoscopy or dermatoscopy uses a tool named dermatoscope magnifying the lesions (usually x3-x10) and helps the dermatologists examine the skin more clearly. For melanoma detection, there are several ways that dermatologists use to avoid unnecessary biopsy, which ABCD rule is the most famous one. This was developed from the rule that dermatologists frequently apply to diagnose skin cancer. Asymmetry in the ABCD rule refers to two sides that do not match for symmetry but match for the other. This can help differentiate between skin lesions that are benign and those that are malignant.

In most situations, the border structure is irregular for malignant growth and even for benign growth. When it comes to benign conditions, the variegated color is usually only one, but in cases of malignancy, it is always two or more hues. When anything is benign, the overall dermatoscopical structure is always very small—about a quarter of an inch—while when something is malignant, it is always larger.

With the advancement of electronic devices and computers, diagnosis of diseases by them have become prevalent named Computer Aided Diagnosis or CAD. Recently, melanoma detection has also been evoked by CAD, which has reduced the number of unnecessary biopsies and detection has also been faster, although not as accurate as biopsy.

In order to diagnose skin cancer speedily at the earliest stage and solve some of the above-mentioned problems, there have been extensive research solutions by developing computer-based systems using image pre-processing and machine/deep learning algorithms.

As per [18], the average accuracy of diagnosis using machine/deep learning models is found to be approximately 98.89% and the best is 100%. The machine-assisted diagnosis developed system will overcome the problem of delay, accuracy, and scarcity of dermatologists in public health.

1.2 Motivation

Out of the generally occurring skin cancers, Melanoma remains to be the most dangerous type of skin cancer. Its detection in early stages is vital for survival, hence Computer Vision techniques are proved to be useful to detect Melanoma in early stages. Furthermore, any of the current attempts at automating the process have not been intuitive enough for actual use by Dermatologists in clinics and also there is a good survival percentage for melanoma if it is identified early and treated appropriately. Reducing mortality can be achieved in part by using accurate screening to detect melanoma early and prolongation of patients' survival. Hence, amalgamation of computer vision techniques is intended to be done along with Deep Learning to detect Melanoma in early stages to save life.

1.3. Problem Definition

Detection of Melanoma skin cancer using image processing techniques, deep learning algorithms like AlexNet, Resnet50 and EfficientNetB7 by taking images of lesions as input through local application.

2. Literature Review

According to Adegun and Viriri (2020) [2] until now, several computer-aided diagnosis and detection systems developed in the past. The complex visual qualities of the skin lesion photographs, such as jagged edges and uneven features, have impeded their effectiveness. To get beyond these restrictions and enable automatic melanoma lesion recognition and segmentation, a deep learning-based approach was put forth. A refined encoder-decoder network is suggested for effective feature extraction and learning. The system uses a multi-stage, multi-scale technique along with a softmax classifier to classify melanoma lesions pixel by pixel. They created a novel method known as Lesion-classifier, which uses the outcomes of pixel-wise classification to classify skin lesions as either melanoma or non-melanoma. Using the ISIC 2017 dataset, they obtained accuracy and dice coefficients of 95% and 92%. On PH2 datasets, accuracy and dice coefficients of 95% and 93% were attained.

The automatic skin lesion analysis of dermoscopy images is still a difficult problem, according to Song et al (2020) [8].
An end-to-end multi-task deep learning system for autonomous skin lesion analysis was proposed in this research. The suggested framework is capable of concurrently completing tasks for segmentation, classification, and skin lesion detection.
Data preparation is the first step in the proposed framework, where dermoscopy images with arbitrary sizes are fed as the inputs. It is then divided into: - Image Size Organization and zero-center Normalization. After data preparation, the processed images are sent to the deep learning model architecture. Feature pyramid network (FPN), region proposal network (RPN), and three convolution subnets make up the suggested model architecture. These subnets are utilized independently for segmentation, detection, and classification. The framework accepts images of any size as input and directly provides the melanoma kind, position, and boundary without requiring any additional post-processing activities.

Given that manual dermoscopy detection is heavily reliant on physicians' clinical experience and that the intricacy of dermoscopic images presents significant challenges for categorization, Gong, Yao, and Lin (2020) [4] suggested a decision-making technique in this model. Based on multiple pre-trained CNNs, the study combined many CNNs using block ideas, and then used multiple blocks to make decisions. The research used a total of 3 algorithms namely Decision fusion, StyleGANs and CNN. With the method proposed by the paper it was able to alleviate the uneven distribution of dermoscopic images, along with automatically classifying the dermoscopic images.

In this study, Naemm et al. (2020) [3] compares the accuracy of CNN classifiers when evaluated on unpublished datasets and analyze the classifiers. Out of the 5112 studies that were found, 55 reputable studies were chosen. This study's primary goal is to compile the most recent information from these studies and examine the available approaches for deep learning-based melanoma detection diagnosis. Furthermore, this research also proposed a taxonomy for melanoma detection.

According to Alizadeh and Mahloojifa (2018) [12] traditional Melanoma detection techniques, dermatologists use the biopsy method. This method has its own limitations as it involves pain, time and cost. It involves tissue removal and analysis. The main motive of this paper is that it introduced an application for Melanoma detection which is available on Android as well as iOS. The application used two methods for classification. SVM and Naive Bayes were the algorithms used. The accuracy and sensitivity of both the algorithms was quite high. On the other hand, the application was user friendly too. The final results were displayed on the smart- phone for the dermatologists to see.

According to Ashraf et al (2020) [10], deep learning algorithms are hampered by the restricted number of images available. Based on this line of inquiry, this work suggests an intelligent Region of Interest (ROI) based system that uses the transfer learning technique to distinguish between nevus cancer and melanoma. This paper proposed a fully automated transfer learning-based improved CAD solution to detect melanoma accurately. And also designed an augmentation-based CAD for melanoma to handle class imbalance The Kmean, CNN, and AlexNET algorithms were employed. The suggested method applies augmentation after using ROIs taken from the upgraded K-mean algorithm. After that, a transfer learning technique is used to classify these photos, producing very good results. Images based on Region of Interest were employed in the suggested approach to assist in extracting only discriminative characteristics.

According to Ali, Li, and Yang (2020) [1], early melanoma identification is critical for survival and subsequent therapy. The task involves categorizing the photographs as either positive or negative. With the aid of the ABCD (Asymmetry, Border, Colour, Diameter) rule and the application of several algorithms for the segmentation of provided image. Multilevel Otsu Thresholding was employed in this paper to achieve segmentation. Solution efficiency is raised via dynamic thresholding.

According to Yang et al. (2018) [7], 75% of people with melanoma die from the disease when it is discovered later

on. Additionally, it may spread to other bodily parts. Regional Average Pooling, a weighted global average pooling operation, was proposed in this study. Classifiers can better focus on the region of interest with the use of this regional average pooling technique. RankOpt was utilized for the CNN model's post-processing. It strengthens the CNN model's resilience. A CNN of 50 layers deep, called ResNet 50, was employed. The picture can be divided into more than 100 categories by the pretrained network. ResNet 50 increased the model's accuracy.

Ahn et al. (2017) [6] addressed in this study the challenges that traditional segmentation techniques encounter in situations such as blurry lesion borders, uneven background, etc. This study presented a computer-aided diagnosis method that uses the RSSLS framework and saliency-based lesion segmentation technique on dermoscopic pictures to detect and classify melanoma skin cancer. For accurate detection, they employed the Robust-Saliency based skin lesion segmentation (RSSLS) framework. To put it briefly, a computer application-based approach was created to accurately classify skin cancer via image segmentation.

Walaa Gouda and others [13] used deep learning models such as CNN, Resnet50, Inception Net v3 and Inception Resnet for classifying skin images into melanoma or benign. The authors used ESRGAN (Enhanced Super-Resolution Generative Adversarial Networks) as a pre-processing step for improving the quality of images before classification. The authors achieved 83.2% accuracy rate from CNN, 83.7% from Resnet50, 85.8% from InceptionV3, and 84% from Inception Resnet on ISIC 2018 dataset.

According to Qasim Gilani, S., Syed, T., Umair, M [15], spiking neural networks are widely used for classification of skin cancer. They employed deep spiking neural networks using the surrogate gradient descent method to classify images into melanoma/non-melanoma on ISIC 2019 dataset. An overall accuracy of 89.57% and an F1 score of 90.07% was achieved using the proposed spiking VGG-13 model.

T. Imran and others [14] used a pre-trained CNN with ACO (Ant-Colony Optimization) for the feature selection phase. The authors also used a variety of pre-processing steps such as histogram equalization, gamma correction, and white balance adjustment, to enhance visibility, quality, and make color corrections. The highest accuracy of over 98% was attained in addition to training time being reduced and prediction speed maintained.

After reviewing fifteen studies, our study found that only one or two of them used a local application to identify melanoma skin cancer. Furthermore, machine learning or deep learning were employed in the majority of the studies. As a result, this gap is located and closed by employing local application and machine learning and deep learning techniques in this study. It would be more user-friendly in this approach.

3. Methodology

It was a local application which can be easily used by doctors and patients. It classified skin into either Non-melanoma Lesion or Melanoma Lesion by internally using image classification algorithms. User uploaded the image of the skin on application and after classification, user got the result on the application. Eg-It differentiated between lesions of same structure by detailed analysis of images and by some data. Local application took input images either through camera or directly from local storage (e.g. Gallery). Local application differentiated images into 2 classes Melanoma or Non-Melanoma affected skin. And finally the output was shown to the user on screen.

Features-:

i) Login-:

The login feature allowed registered users to login to the app to access all of the features that their account gives them access to. The login screen contained a textbox to enter login credentials such as username and password. The login

screen also contained a buttons named as register, login and forgot passwords.

ii) Registration-:

If the user wanted to create a new account then the user used this feature. With the help of this feature, system got all necessary information of the user which is required for future use. In this feature there was textbox for name, email address, mobile number, birth date and password for taking input data. There was also one button named register information.

iii) Select Image from Device-:

Select image from device feature is for selection of image which is present in device where application is running to upload this image on server to get result from server. In this feature there is one button named as select image from device.

iv) Preprocessing of Image-:

This is server-side feature. This feature includes intensity adjustment, brightness thresholding and detecting edges. This feature is using OpenCV library to fulfill these requirements. This feature also includes hair removal sub-feature. With Otsu's method or any other approach, such as "local thresholding" or even "local histogram equalization and then global thresholding," this feature uses adaptive local thresholding to discover the hair region.

v) Segmentation of Image-:

This segmentation feature takes input image from pre-processing model and performs segmentation on image using OpenCV library. Segmentation divide image into various part called segments (like background of lesion and actual part of lesion). For this segmentation feature uses thresholding methods like Otsu's thresholding method for segmentation of image.

vi) Classification of Image-:

This feature is responsible for classification of a given input image from segmentation model into two classes (melanoma positive / melanoma negative). This feature uses AlexNet, ResNet 50 and EfficientNetB7 for classification of images. This network uses ISIC 2016 dataset for training of model.

vii) Get Result-:

Get result feature is for getting result to user from server whether result of input is positive or negative. This feature has one single get result feature button

The system architecture diagram is depicted in the following Fig 1.

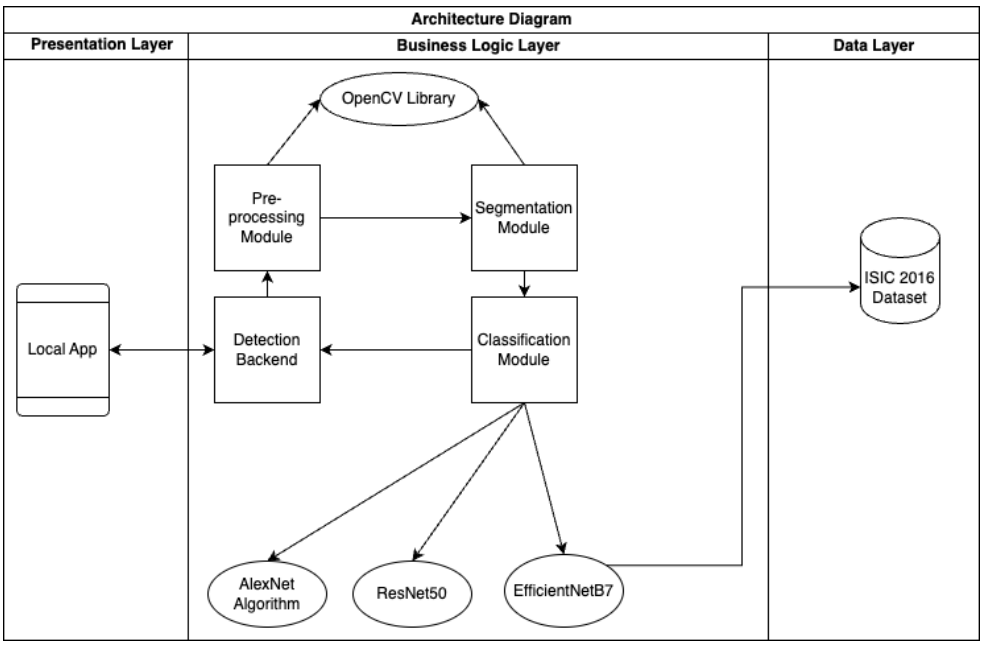

Fig. 1 System Architecture Diagram

The use diagram for the system is given in following Figure 2.

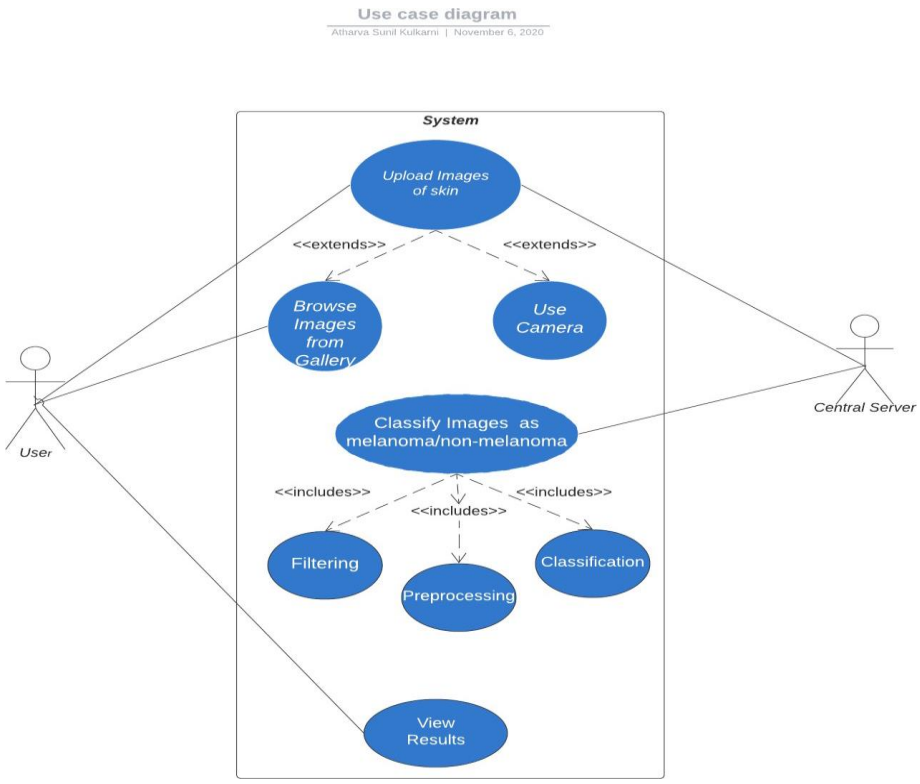

Fig. 2 Use Case Diagram

4. Implementation

OpenCV was used to preprocess the images, segment the images to feature of interest and then ML algorithms such as AlexNet, Resnet50 and EfficientNetB7 were used to classify these images into Melanoma/non-melanoma. The results were displayed to the user through the UI.

The implementation is carried out from scratch without using any open-source libraries.

5. Results and Discussion

The following test case table shows the different scenarios tested for our application-:

Test Case No	Test Case	Actions	Expected Outcome
1	Login with valid credentials	1. The user will first be taken to the login page. 2. The user must input their password and user name in the designated textbox. 3. At last, he or she will press the submit button.	He or she will be taken to the home page for the right credentials after clicking the submit button.
2	Login with invalid username and valid password	1. The user will first be taken to the login page. 2. The user must input their password and user name in the designated textbox. 3. At last, he or she will press the submit button.	When one hits the submit button, an error message stating that your username is wrong will appear on the login page.
3	Login for valid username and invalid password	1. The user will first be taken to the login page. 2. The user must input their password and user name in the designated textbox. 3. At last, he or she will press the submit button.	When one hits the submit button, an error message stating that your password is wrong will appear on the login page.
4	Login for invalid username and invalid password	1. The user will first be taken to the login page. 2. The user must input their password and user name in the designated textbox. 3. At last, he or she will press the submit button.	When one hits the submit button, an error message stating that your username and password are wrong will appear on the login page.
5	Register with all details validated	1. The user will first be taken to the login page. A link for new users will be available here. 2. The user will be taken to the registration page after clicking the link. 3. Entering the essential user information here, he or she will press the register button.	All of the fields will be evaluated in accordance with their respective rules after the register button is clicked. In this instance, registration will be accepted, and the user will be taken to the login screen.
6	Register with invalid username	1. The user will first be taken to the login page. A link for new users will be available here. 2. The user will be taken to the registration page after clicking the link. 3. Entering the essential user information here, he or she will press the register button.	All of the fields will be evaluated in accordance with their respective rules after the register button is clicked. In this instance, registration will not be accepted, and the user will be shown an error window saying username as invalid.

7	Register with invalid password	1. The user will first be taken to the login page. A link for new users will be available here. 2. The user will be taken to the registration page after clicking the link. 3. Entering the essential user information here, he or she will press the register button.	All of the fields will be evaluated in accordance with their respective rules after the register button is clicked. In this instance, registration will not be accepted, and the user will be shown an error window saying password as invalid.
8	AlexNet, Resnet50 and EfficientNetB7 for image classification on training data.	1. Using AlexNet, Resnet50 and EfficientNetB7 on train data, ML classification algorithms will identify the image as melanoma/non-melanoma after applying preprocessing and image segmentation. 2. The back-end will perform the classification, and the front-end will get the results.	Expected Train Accuracy: 89% for AlexNet, 100% for Resnet50, and 83% for EfficientNetB7.
9	AlexNet, Resnet50 and EfficientNetB7 for image classification on test data.	1. Using AlexNet, Resnet50 and EfficientNetB7 on test data, ML classification algorithms will identify the image as melanoma/non-melanoma after applying preprocessing and image segmentation. 2. The back-end will perform the classification, and the front-end will get the results.	Expected Test Accuracy: 78% for AlexNet, 82% for Resnet50, 83% for EfficientNetB7.
10	Receive an Unselected Image in the Result	1. Upon successful login, the user will see an image upload button on the main page. 2. The user will be presented with two choices: gallery or camera. 3. The user will not upload a picture; instead, they will click the "get result" button.	An error message indicating "image not selected" will appear when you click the "Get Results" button.
11	Receive a selected Image in the Result	1. Upon successful login, the user will see an image upload button on the main page. 2. The user will be presented with two choices: gallery or camera. 3. The user will not upload a picture; instead, they will click the "get result" button.	The user will get results after clicking the "get result" button, with the status of skin cancer being "melanoma/benign."

6. Screenshots of the application

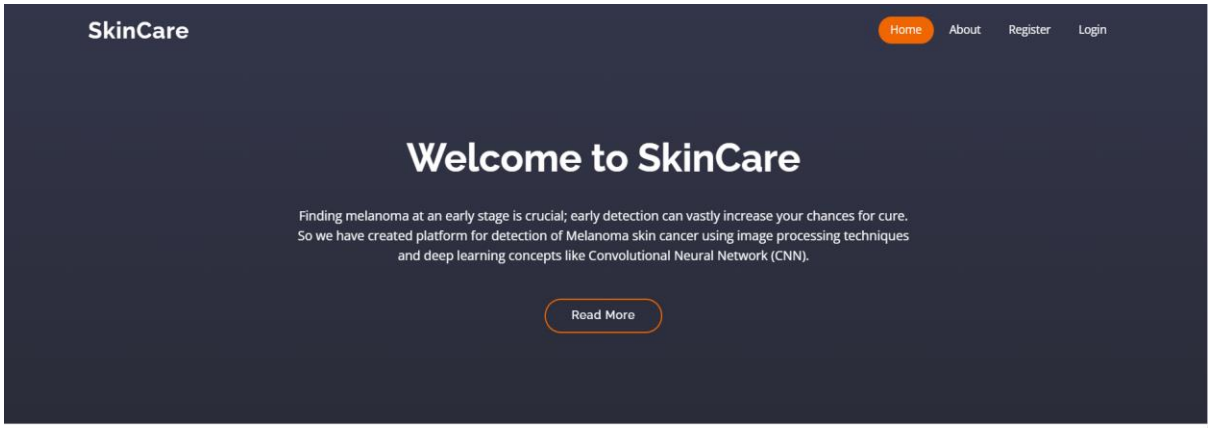

Fig. 3 Home Page

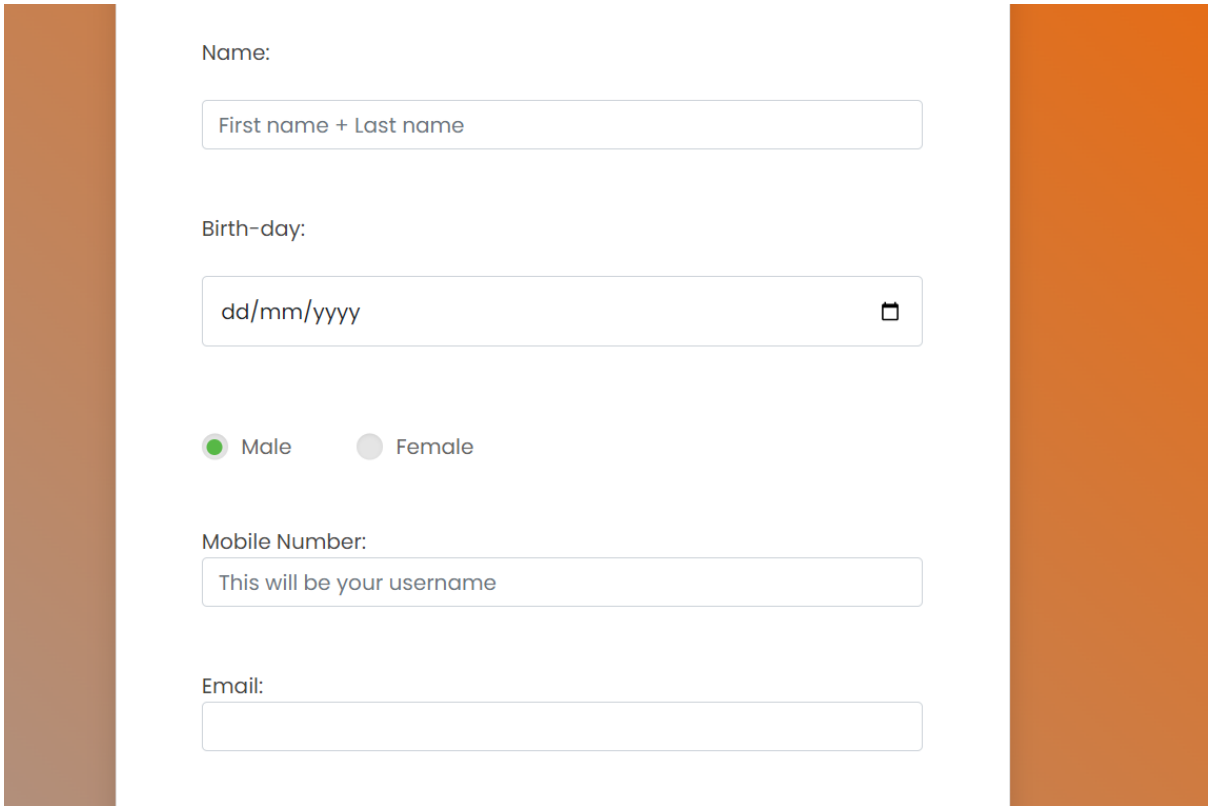

Fig. 4 Registration Page

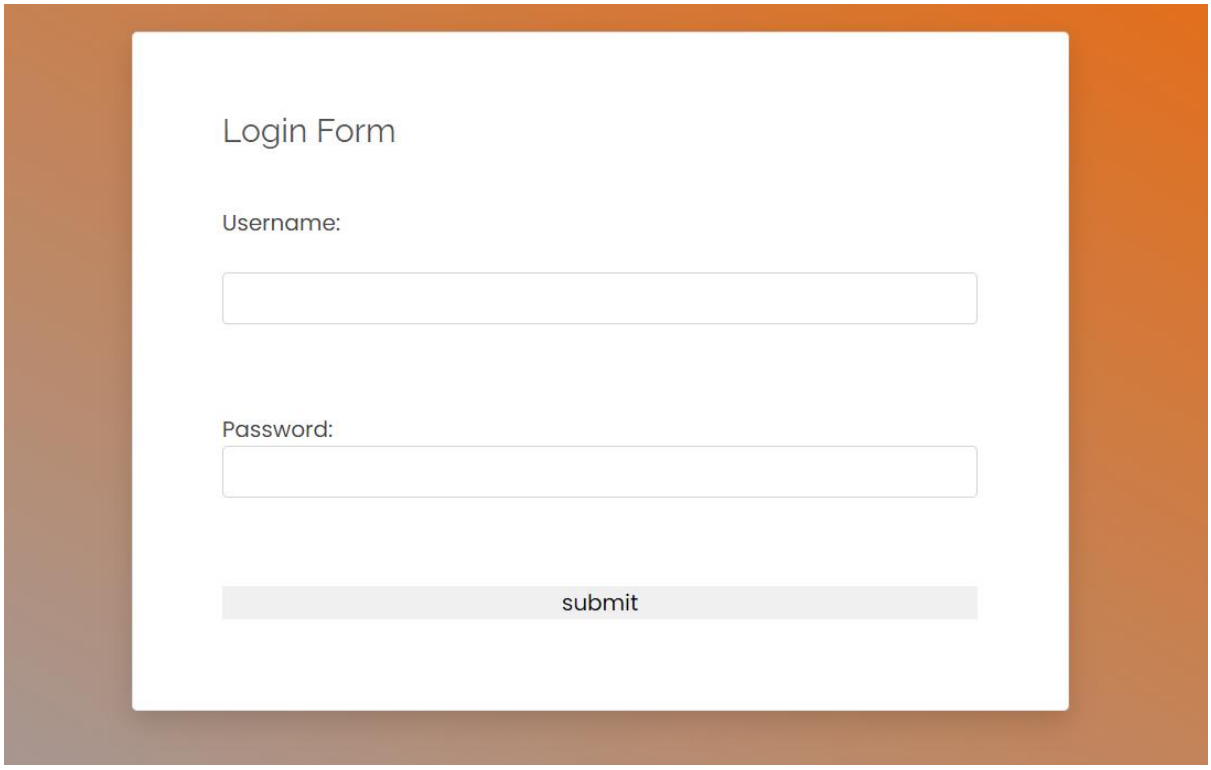

Fig. 5 Login Page

Fig. 6 Melanoma Classification of an input image

Fig. 7 Non-Melanoma Classification of an input image

```
/usr/local/lib/python3.10/dist-packages/torchvision/models/_utils.py:208: UserWarning: The parameter 'pretrained' is deprecated since 0.13 and m
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/torchvision/models/_utils.py:223: UserWarning: Arguments other than a weight enum or `None` for 'weights
  warnings.warn(msg)
Epoch 1/6, Loss: 0.5313665103167295
Epoch 2/6, Loss: 0.4191095223650336
Epoch 3/6, Loss: 0.3759641223587096
Epoch 4/6, Loss: 0.3467765301465988
Epoch 5/6, Loss: 0.3207173948176205
Epoch 6/6, Loss: 0.3021239209920168
Training Accuracy: 89.44%
Testing Accuracy: 78.52%
```

Fig. 8 Accuracy of the model for AlexNet

```
/usr/local/lib/python3.10/dist-packages/torchvision/models/_utils.py:208: UserWarning: The parameter 'pretrained' is deprecated since 0.13 and m
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/torchvision/models/_utils.py:223: UserWarning: Arguments other than a weight enum or `None` for 'weights
  warnings.warn(msg)
Epoch 1/6, Loss: 0.5811197785660625
Epoch 2/6, Loss: 0.37781568337231874
Epoch 3/6, Loss: 0.26911873277276754
Epoch 4/6, Loss: 0.16484620585106313
Epoch 5/6, Loss: 0.07768207765184343
Epoch 6/6, Loss: 0.03624134580604732
Training Accuracy: 100.00%
Testing Accuracy: 82.81%
```

Fig. 9 Accuracy of the model for Resnet50

```
Loaded pretrained weights for efficientnet-b7
Epoch 1/6, Loss: 0.6491626352071762
Epoch 2/6, Loss: 0.5655803391709924
Epoch 3/6, Loss: 0.5086678974330425
Epoch 4/6, Loss: 0.4803602956235409
Epoch 5/6, Loss: 0.4367702854797244
Epoch 6/6, Loss: 0.41273813880980015
Training Accuracy: 83.19%
Testing Accuracy: 83.20%
```

Fig. 10 Accuracy of the model for EfficientNetB7

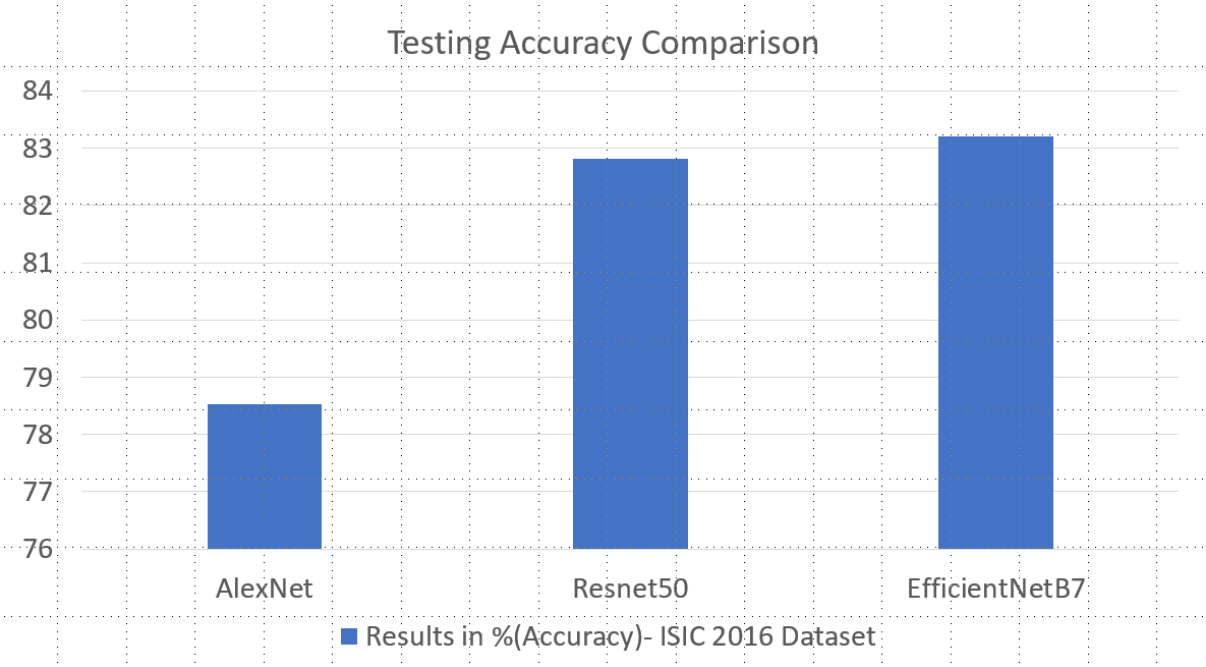

Fig. 11 Testing Accuracy Comparison Chart

The above figure shows the performance of 3 models on testing data. It can be seen that EfficientNetB7 is the winner with 83% testing accuracy followed by Resnet50 and AlexNet. This is quite evident given the extra number of hidden layers and the use of compound scaling method in EfficientNetB7 to optimize the network's depth, width, and resolution simultaneously.

7. Conclusion

Detection of melanoma cancer in the early stage is very important for further treatment of cancer. The solution proposed was for classification of melanoma cancer images by using deep learning algorithms like AlexNet, Resnet50 and EfficientNetB7 along with image pre- processing with the help of OpenCV module. An overall testing accuracy of 83.2% was achieved for EfficientNetB7 Algorithm which was a considerably high accuracy given the overall complex task of cancer detection. The other algorithms such as Resnet50 achieved testing accuracy of 82% and AlexNet of 78% was quite good given the complex nature of image classification.

8. Limitations

1. The application requires good internet connectivity. Slow internet can increase delay in outcome.
2. Users can only upload one image at a time, no more than that.

9. Future Work

1. Accuracy can be improved by experimenting with the hyperparameters, learning rate and optimizer and hence reduce the number of false positives/negatives.
2. Feature of uploading multiple images at a time can be added since there can be multiple areas on the skin where cancer can be caused.
3. Features can be extracted from a pre-trained neural network and then classification models like SVM can be trained on it.

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Secure Encryption of Documents and Smart Complaint Management for Banking Applications

Tirthraj Mahajan[1], Advait Joshi[2]

[1]Tirthraj Mahajan; SCTR's Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, tirthraj2004@gmail.com
[2]Advait Joshi; SCTR's Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, advaitkjoshi@gmail.com

Abstract

This paper explores the integration of secure authentication and document encryption in web applications, focusing on banking systems. It examines the theoretical foundations and practical implementations of cryptographic techniques such as SHA-256, RSA, and modern encryption algorithms. Additionally, it discusses the challenges and best practices for ensuring data security and privacy. A banking web application case study is presented to illustrate the real-world application of these security measures. This paper also proposes a method to arrange users' complaints in descending order of priority using natural language processing.

Keywords: Securing Authentication, Document Encryption, Cryptographic Algorithms, Token-based authentication, Natural language processing

1. Introduction

In the digital age, banking web applications have become an important tool for managing financial transactions. These applications handle sensitive data and personal information. Thus, ensuring security is paramount in such applications. The increasing prevalence of cyber threats such as data breaches, unauthorized access, identity thefts, etc. requires robust security measures. The paper's primary objective is to analyze and implement secure authentication and encryption methods for secure document uploads, in the context of web banking applications. The focus of the paper is utilizing cryptographic techniques, specifically Scrypt for hashing, RSA for asymmetric encryption, AES for symmetric encryption, and JWT for secure Token-based authentication. By integrating these methods, the paper aims to enhance the security of user authentication processes and the encryption of sensitive documents. This will ensure that user data is protected both in transit and at rest, providing a secure environment for banking operations.

Scope: This paper will concentrate on the following key areas within the domain of secure authentication and document encryption:

1) Cryptographic Hash Functions (Scrypt): An exploration of Scrypt and its properties, and its application in securing passwords
2) Asymmetric Cryptography (RSA): An analysis of the RSA algorithm, including key generation, encryption, and decryption processes
3) Symmetric Cryptography (AES): Discussion of AES encryption techniques for securing documents.
4) Token-Based Authentication (JWT): Examination of JWT, its structure, and its application in secure authentication.
5) Integration of Authentication and Encryption: Strategies for combining secure authentication mechanisms with document encryption to provide a seamless and secure user experience.

Along with all the banking functionalities, a bank application accepts user complaints. For a bank with a large user base, it becomes difficult to scan through all the complaints manually. These complaints can vary in urgency levels,

depending on the severity of the issue. Urgent and sensitive complaints must be resolved with priority. For example, any complaint related to unauthorized transactions through card or Internet banking must be addressed at the earliest to avoid any further mishaps. To make sure that urgent complaints and queries are flagged and addressed on priority, there is a need to automate complaints management in bank applications. Modern techniques of natural language processing and deep learning can be used to develop such a system.

2. Literature Survey

In [1], a Support Vector Machine (SVM) is used to classify newspaper headlines. They have used TF-IDF vectors along with SVM and have claimed good accuracy over a small dataset as compared to other models which need a bigger dataset to reach a good accuracy. Further improvements on SVM-based models are proposed in [2] where they have introduced the concept of uneven margins. The even margin-based model outperforms other models for the task of information extraction. Though there is a difference between information extraction and natural language processing, there is a possibility that this newly proposed model will give better results for NLP tasks too. In [3], SVM is used for sentiment analysis on Japanese text. Like [1], they also have used the TF-IDF. They have compared the accuracy of TF-IDF, CNN and BPCNN. Out of the three, TF-IDF shows the highest accuracy which consistently is distributed around 90% for all the 70 experiments performed. In [4], they compared the results of sentiment analysis on the Twitter dataset. They have used a total of 5 machine learning algorithms and 5 ensemble algorithms. The research reveals that the ensemble algorithms show 3% to 5% better performance as compared to other machine learning algorithms. Similar work is done in [7] on social media posts, blogs, and reviews of products. They have used WordSenses and Synsets to improve classification, at the cost of increasing the size of the feature vector, which demands higher computation power. In [5], they used SVM for the classification of documents in the Hindi language in predefined categories. They have claimed a 100% accuracy. Part of speech tagging is an important technique in NLP. It is mainly used for information retrieval. SVM is used for tagging part of speech in [6] for the Malayalam language. With 20,000 words in a Lexicon, the model shows 63% accuracy, whereas for a Lexicon with 1,80,000 words, the accuracy is 94%. Hence, it can be said that SVM classification performs well in identifying the part of speech. Similarly, in [8], they have used an SVM-based approach to tag parts of speech for the Telugu language. SVM is used for the classification of natural language data available in different forms. SRS (System Requirement Specification) document analysis is performed in [9]. They have also used SVM SVM-based approach for extracting elements in SRS documents. The proposed model has an F-measure of 72.1%.

In [10], along with the commonly used machine learning algorithms, they have tried the deep learning approach as well. They have used artificial neural network (ANN) for NLP. In [11], artificial neural networks and convolutional neural networks are used and compared for the classification of poets. They have used TF-IDF for ANN and word embeddings for CNN. They found the multilayered perceptron (ANN model) has the highest performance. Based on all the related studies, we decided to train two models – one on SVM and the other on ANN.

Cryptographic hash functions are essential in cryptography to achieve security goals such as verifying authenticity, creating digital signatures, implementing digital time stamping, and authenticating entities. They are also closely linked to other key cryptographic tools, such as block cyphers and pseudorandom functions. A cryptographic hash function is an algorithm that transforms a message of any length into a fixed-length hash code or digest. Hash functions are vital in cryptography, serving various security purposes [12]. In [13], the authors discuss the distinction between traditional hashing and key derivation functions. Passwords are never stored in plain-text format; instead, their hashes are generated and stored in the database. SHA256, SHA512, etc. are a traditional way of storing passwords and are not secure any more as they are vulnerable to cracking using methods like lookup and Rainbow tables. This is the reason why, we decided to use one of the latest key derivation functions, Scrypt. It is a hashing algorithm which makes use of a password-based key derivation function and takes a large computation cost. For encryption of documentation, we proceeded with the Advanced Encryption Standard (AES). The current Digital Encryption Standard (DES) is inadequate for today's data security requirements due to its short 56-bit key, which can be easily broken by brute force

attacks according to [14]. [15] explains the process of AES Algorithms. The AES algorithm supports combinations of data and key lengths of 128, 192, and 256 bits. It processes data in 128-bit blocks, which are divided into four basic operational blocks. Full encryption involves Nr rounds of iteration, with Nr being 10, 12, or 14 rounds for key lengths of 128, 192, and 256 bits, respectively. The cypher key is used to encrypt using the public key and decrypt using the private key of the user. For this, we have used the RSA algorithm [16] as it is the most used for such types of asymmetric key encryption. Also, for authentication purposes, we took care of the SQL Injections using prepared statements and regex expression matching. These injection attacks can be used to retrieve information from databases and bypass security mechanisms. These attacks rely on manipulating pre-defined logical expressions within a query by injecting operations that yield always-true or always-false results [17]. In [18], it is explained that JSON Web Tokens offer a scalable solution with notable performance advantages for managing user access in large, decentralized distributed systems. They are better than traditional session-based authentication. We stored information which remains persistent in the JWT. [19] explains the "User update problem" and thus we pass only data that remains persistent as payloads. The payload is then encrypted using an encryption key called the JWT secret. These are called access tokens and are passed along with each subsequent request by the client which is decrypted by the server and the access control data from the token is retrieved.

3. Proposed Methods

This section details the methodologies and procedures used to implement secure authentication and document encryption in our banking web application. We utilized established cryptographic techniques to ensure data security. The methodologies are described under separate subheadings for clarity.

3.1 Input Validation using Regular Expressions

To prevent injection attacks and ensure the validity of user inputs, we used Regex for input validation during registration and login processes.

- **Procedure:**
  1. Name Validation: It has been ensured that the name does not contain any special symbols and is not empty
  2. Username Validation: It has been ensured that the username does not contain any special symbols and is not empty
  3. Email Validation: Ensured that the email complied with the valid format and belonged to a known provider
  4. Password Validation: Ensured that the passwords meet the complexity requirements

Regex validation was the first line of defence, that alone was not sufficient on its own to protect against all types of injection attacks

3.2 User Existence Check Before Registration

To avoid duplicate registrations and ensure the uniqueness of each user, we checked if the user already exists in the database before proceeding with the registration.

- **Procedure:**
  Database Query: After receiving a registration request, a query was performed to check whether the email address was already registered.

  Conditional Registration: If the email address existed, the registration process was halted, and an appropriate message was returned to the user.

Note: To prevent SQL injection, we used parameterized queries or prepared statements for database interactions. This approach ensured that user inputs were treated as data, not as executable code.

3.3 Password Hashing and Salting (Scrypt)

We have used the Scrypt algorithm to hash user passwords. To enhance security, we have also applied salting, a process that involves adding a unique random string to each password before hashing. This prevents attackers from using precomputed hash databases (rainbow tables) to crack passwords.

- **Procedure:**

  1. User Registration: When registering a user, a unique salt was generated with a secure random number generator.

  2. Hashing: The password and salt were concatenated and then hashed using the Scrypt algorithm.

  3. Storage: The resulting hash and salt were stored in the database in a combined format.

- **Implementation:**

```
const { scryptSync, randomBytes } = require('crypto')
class Cryptography{
    generateSalt(){
        return randomBytes(8);
    }
    generateSaltHash(password){
        const salt = this.generateSalt().toString('hex');
        const hashedPassword =  scryptSync(password, salt, 64).toString('hex');
        return `${salt}:${hashedPassword}`;
    }
}
```

3.4 Asymmetric Key Encryption using RSA

RSA was employed to encrypt the AES keys used for document encryption, ensuring that only authorized users with the correct private RSA key can decrypt the documents

- **Procedure:**

  1. **Key Generation**: RSA key pairs (public and private keys) were generated for each user

  2. **Key Encryption**: The user's private key was encrypted with the server's secret key, using the user's salt value used as the Initialization Vector (IV). This ensured that the private keys remained secure even if the database was compromised, and could only be decrypted by the server.

  3. **Storage**: The public key and the encrypted private key were stored in the database.

By following this procedure, we ensured a robust and secure method for handling key management in our application

- **Implementation:**

```
const { generateKeyPairSync } = require('crypto')
class Cryptography{
    generateKeyPair(){
        let  { privateKey , publicKey } = generateKeyPairSync('rsa', {
            modulusLength: 2048,
            publicKeyEncoding:{
                type: 'spki',
                format: 'pem',
            },
            privateKeyEncoding:{
                type: 'pkcs8',
                format: 'pem',
            }
        })
        return {privateKey: privateKey, publicKey: publicKey}
    }
}
```

3.5 Token Based Authentication

We have implemented JWT (JSON Web Token) for secure token-based authentication. JWTs are used to verify the identity of users after login and ensure secure sessions.

- **Procedure**
  1. **Token Generation:** A JWT was generated after a successful login. The payload contained user information and was signed with the server's secret key.
  2. **Token Verification:** For subsequent requests, the JWT was sent in the HTTP headers and verified on the server with the same secret key.

- **Implementation**

```
const jwt = require('jsonwebtoken')
class JSON_WEB_TOKEN{

    // Init payload of the jwt token

    createPayload(userId,name,username,email,iv,role){
        return {
            uid: userId,
            name: name,
            username: username,
            email: email,
            iv: iv,
            role: role
        }
    }

    createToken(payload){
        // return the signed jwt token
        return jwt.sign(payload, SECRET_KEY, { expiresIn: '7d' })
    }

    validateUserToken(userToken){
        try {
            const decodedToken = jwt.verify(userToken, SECRET_KEY);     // fetch
the decoded token using the secrete key and userToken
            // console.log(decodedToken);

            // If token is not verified, then it will throw an error

            if (decodedToken.exp < Math.floor(Date.now() / 1000)) {     // check
if the token has expired
                return { valid: false, reason: 'Token has expired' };
            }

            // return valid token

            return { valid: true, decodedToken: decodedToken };
        } catch (error) {
            return { valid: false, reason: 'Invalid token: ' + error.message };
        }
    }
}
```

3.6 Symmetric Key Encryption using AES

AES (Advanced Encryption Standard) was used for encrypting documents due to its efficiency and security. AES operates using a symmetric key, which means that the same key is used for both encryption and decryption.

- **Procedure**
  1. **Encryption:** The content of the uploaded document was encrypted with a randomly generated AES key.
  2. **Key Management:** Then the AES key was encrypted using RSA and stored securely.
  3. **Storage:** The encrypted document and the encrypted AES key were stored in the database.

- **Implementation**

```
const { createCipheriv, createDecipheriv } = require('crypto');
function encipherFile(fileContent,salt){
    const cipher_key = randomBytes(32).toString('hex')
    const cipher = createCipheriv('aes-256-cbc', Buffer.from(cipher_key, 'hex'),
salt);
    let encipheredFileContent = cipher.update(fileContent);
    encipheredFileContent = Buffer.concat([encipheredFileContent,
cipher.final()]);
    return {content: encipheredFileContent, key:cipher_key}
}
```

3.7 Integration of Authentication and Encryption

To provide a seamless and secure user experience, we integrated the above authentication and encryption mechanisms.

- **Workflow**
  1. **User Login:** The user logs in and receives the JWT
  2. **File Upload:** The user uploads the document, which is then encrypted using AES. The AES key is encrypted using the user's RSA public key
  3. **File Access:** When the user wants to access the document, the AES is decrypted using the RSA private key and then the document is decrypted using the AES key

Figure 1 explains in detail, the flow of the encryption process.

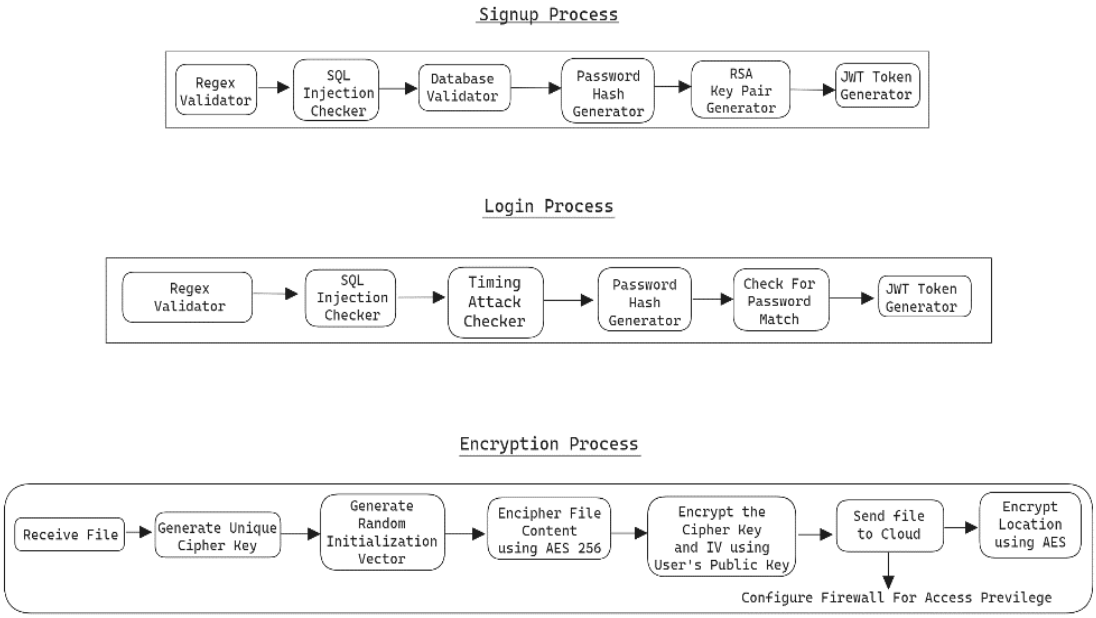

Fig. 1 Encryption flowchart

3.8 Complaint Management Model

To automatically determine the urgency of the complaint, we followed the following steps:

1. Dataset: Created a custom dataset with 222 complaints and corresponding urgency values from 0 to 1, where 0 is the least urgent and 1 is the most urgent.
2. Vectorization: Vectorized the dataset by using tf-idf vectorizer
3. Vocabulary generation: Generated a vocabulary of 600 words from the dataset. Figure 2 shows the word cloud of the vocabulary:

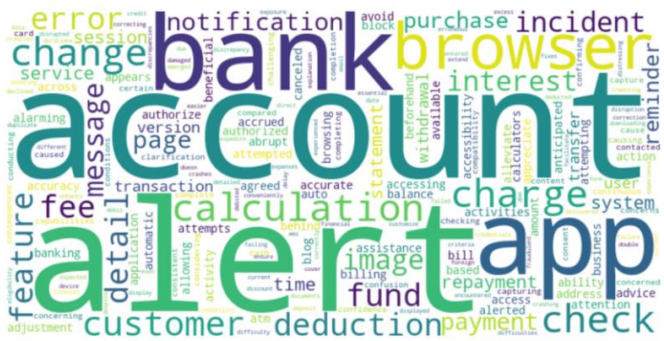

Fig. 2: Word cloud of the vocabulary

4. Splitting data: We kept 80% data for training and 20% data for testing
5. Model training
6. Get the mean squared error from the testing data
7. Input all the complaint sentences to the model and get the complaints in descending order of urgency as the output.

4. Results and Discussion

We trained two models for urgency detection:

1. Support Vector Machine (SVM)
2. Artificial Neural Network (ANN)

Figure 3 shows the summary of the ANN model.

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 128)               76928

 dense_1 (Dense)             (None, 64)                8256

 dense_2 (Dense)             (None, 64)                4160

 dense_3 (Dense)             (None, 1)                 65

=================================================================
Total params: 89409 (349.25 KB)
Trainable params: 89409 (349.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Fig 3: Model summary

Table 1 shows the comparison of mean squared error, mean absolute percentage error and the R2 score of both models.

Table 1: Comparison of models

Metric	SVM Model	ANN Model
Mean Squared Error (MSE)	0.0097	0.0075
Mean Absolute Percentage Error (MAPE)	0.1591	0.1149
R2 Score	0.8085	0.8514

The histogram in Fig 4 compares the MAPE and the R2 Score of SVM and ANN models. ANN model shows lower error and greater R2 Score than the SVM model. Hence, the ANN model has the best performance. Therefore, we selected this model for our application.

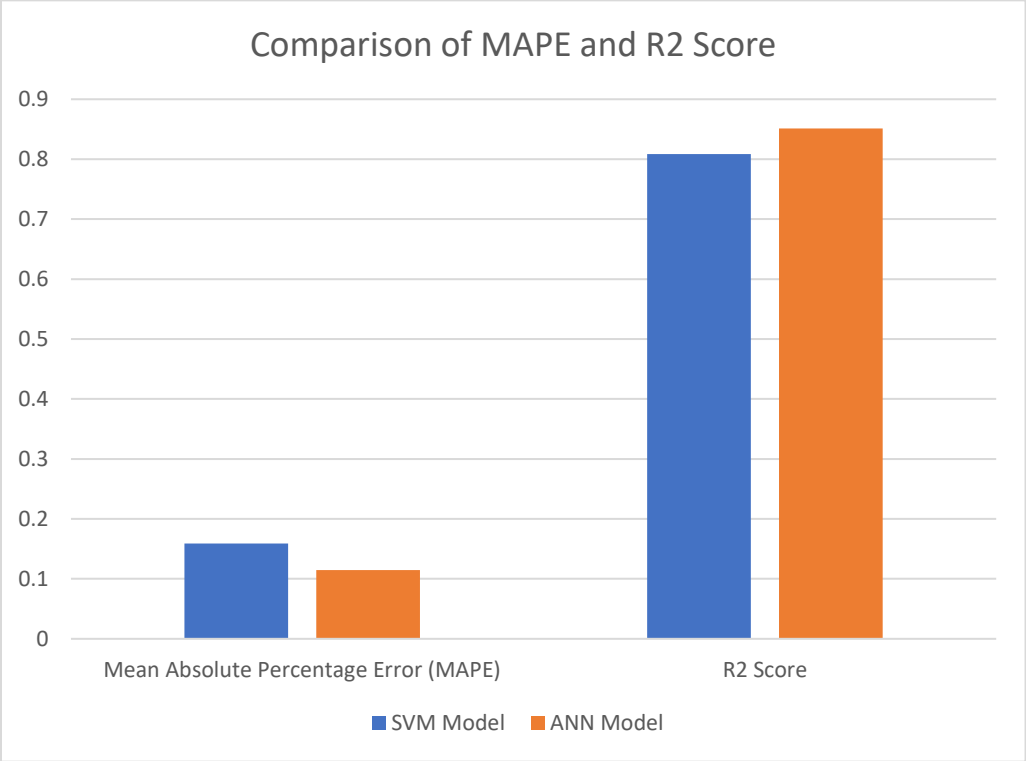

Fig 4: Comparison of MAPE and R2 Score

Example of 5 sample complaints:

1. "I have noticed an unauthorized transaction on my account dated May 10th for $50. This transaction was not made by me, and I am very concerned about the security of my account. I need this resolved immediately as it is affecting my balance and causing me significant stress. Additionally, I would like to know what measures are being taken to prevent such incidents in the future."
2. "My credit card payment due date was suddenly changed without any notification. This caused me to miss the payment, which I believe is unfair and needs to be rectified. I have always been prompt with my payments, and this sudden change has disrupted my financial planning. Please address this issue regarding the expiry of my card, as it was not my fault."

3. "I have been charged twice for the same purchase at your store on April 25th. This has resulted in an unnecessary deduction from my account, and I am now short on funds for other expenses. Please refund the duplicate charge as soon as possible and confirm that this will not happen again. I also suggest reviewing your payment processing system to avoid such errors."
4. "I received my monthly statement, and there is a misprint in my name. It is spelt incorrectly and should be corrected in your records. This kind of error can lead to issues with identity verification and other banking services. Please update your records and send me a corrected statement. I would appreciate confirmation once this is done."
5. "There is a typo in my passbook for the entry on March 3rd. It shows the wrong transaction description, which is a minor issue but needs correction for accurate record-keeping. Maintaining correct records is important for my financial tracking. Please update the passbook entry and send me a corrected version. This will help me keep my financial documents in order."

Table 2 shows the score that the model assigned to each complaint.

Table 2: Urgency score of complaints

Complaint ID	Urgency Score
1	0.8539581
2	0.8328156
3	0.8988212
4	0.67656535
5	0.7136923

Hence, the model will return the complaints in order of IDs: 3, 1, 2, 5, and 4, where 3 is the most urgent and 4 is the least urgent. Fig 5 shows the line graph of the urgency score of all 5 complaints after sorting.

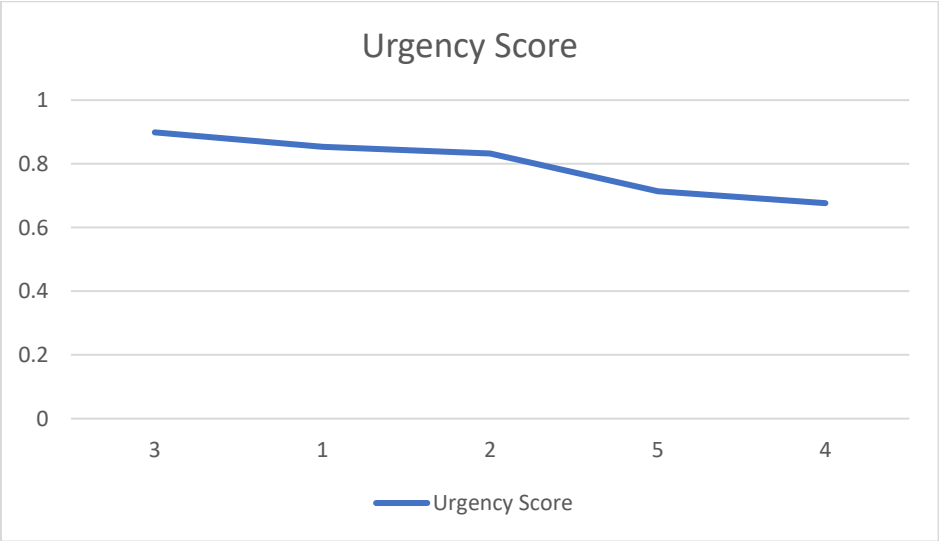

Fig 5: Comparison of MAPE and R2 Score

5. Conclusion

We presented a comprehensive approach to secure authentication and encryption of user documents in a web application. Our solution integrates both symmetric and asymmetric encryption techniques to ensure robust data protection and user privacy. Our approach follows industry best practices, incorporating strong cryptographic methods and secure key management techniques. Future work may include exploring more advanced key management techniques, integrating multi-factor authentication, and continuously updating cryptographic practices to stay ahead of emerging threats. Natural language processing can be effectively used to detect the urgency level of a statement. Regression models based on support vector machine, and artificial neural networks are effective in determining the urgency score of the complaints in the bank app. Using this score, it is possible to sort the complaints, thus adding to faster addressing of highly urgent complaints. The ANN-based model with an R2 score of 0.8514 performs better than the SVM model which has an R2 score of 0.8085. This can be further enhanced by increasing the dataset size and applying LSTMs and transformers. Further research can be done for the classification of complaints into various categories so that they can be transferred to the required department.

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Design and Implementation of 8 - Bit ALU using Verilog

Aarti Jagtap [1], Niveda Pagdhare [2] & Prachi Vitekar [3]

[1]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, aartijagtap2002@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, niveda10p@gmail.com
[3]Student; SCTR's Pune Institute of Computer Technology, (E&TC), Pune, Maharashtra, India, prachivitekar@gmail.com

Abstract:

The goal of the Research work is to create an autonomous output validation system by integrating the clock system in an 8-bit arithmetic logic unit (ALU) using Verilog. This ALU has an 8-bit data width and uses a clock mechanism that synchronises with positive edges so that it can review outputs after each operation without needing to be manually modified for certain line inputs. The ALU automatically evaluates outputs at the positive edge of each clock cycle, ensuring correctness and dependability. This is accomplished by integrating a clock-driven output validation mechanism. By doing away with the necessity for manual intervention, this simplifies the verification procedure and boosts overall operational effectiveness. The design's code execution verified its functioning in a real-time setting by utilising FPGA implementation, guaranteeing smooth integration and dependable performance. Furthermore, thorough analysis with Xilinx tools revealed information on route delays and device utilisation, which was crucial for optimising the design for real-world use.

Keywords: ALU, Verilog.

1. Introduction

Arithmetic Logic Units (ALUs) are essential to digital electronics and computers because of their effectiveness and utility. One of the most important developments in the effort to improve computing power is the idea of an 8-Bit ALU strengthened with an integrated clock mechanism. This research combines the accuracy of clock-driven assessments with the simplicity of ALU operations, removing the need for human involvement when choosing operating modes. The particular feature of this work is the addition of a clock that integrates the examination of output results presented by different Operations. The ALU's output is examined at the positive edge of every clock cycle, providing an exacting assessment of each operation's outcome without the need for human interaction. This automatic validation guarantees accuracy and consistency in the calculation result while also speeding up the evaluation process.

Most importantly, this work heavily relies on the use of Xilinx tools. Using Xilinx's capabilities, Synthesis and simulation of Verilog Module, device utilisation and route delays were carefully tracked and examined. The code for the work was run on a Field-Programmable Gate Array (FPGA), demonstrating its real-time applicability and practical viability. Through the integration of an 8-Bit ALU's capabilities with a clock-based evaluation system, this work represents an innovative approach for evaluation in digital computing. Its importance in accelerating computing operations without reducing accuracy and efficiency is demonstrated by the easy integration of hardware and software as well as the automation of output validation.

1.1 Literature Survey

In the literature, there are several studies related to the design and implementation of ALUs using Verilog and FPGAs. Some of these studies are discussed below:

In the paper authored by Sanju et al. [2] , the full-swing gate diffusion input (GDI) technique is used to optimize a 4-bit Arithmetic Logic Unit (ALU) by delay-time improvement. Through the use of 130nm technology and HSPICE simulation, the altered ALU exhibits better power, delay, and energy efficiency performance metrics. This improved ALU architecture indicates that it can be used in low-power and high-speed applications, which means that it can be used to a variety of digital processing scenarios, such as microprocessors and digital signal processors (DSPs).

The design and analysis of a 32-bit Arithmetic Logic Unit (ALU) using reversible gates on FPGA is the primary focus of the paper by Swamynathan et al. [3]. The potential of reversible gates in low-power computation and information processing has drawn attention. The work presumably contributes to the field of reversible logic and its use in hardware design by examining the efficiency, advantages, and implementation of these gates in the ALU design inside the FPGA architecture.

The 18th International Conference based on Intelligent Systems Design and Applications (ISDA 2018) featured a paper by Shirol et al. [5], that presents a novel design and implementation strategy for an 8-bit and 16-bit Hybrid Arithmetic Logic Unit (ALU). It is possible that the hybrid ALU incorporates components or features from several ALU designs in order to improve usefulness or performance. The work presumably contributes to the advancement of ALU design paradigms by describing the design methodology, implementation specifics, and possible benefits of this unique hybrid ALU architecture.

Chandralekha et al. research [6], which was presented at the IEEE 5th International Conference (ICCCA) in 2020, focuses on designing Reversible Arithmetic Logic Units (ALUs) with a bit count of 8 and 16 that are intended for low-power applications. It probably goes over the design principles and practical applications of these reversible ALUs, highlighting how they can significantly cut down on power use in digital circuits. By assessing the effectiveness and applicability of the reversible ALUs that were built for low-power computing, the study most likely advances the field of energy-efficient hardware design.

2. Proposed Method

An organised and methodical approach provides a proposed approach for creating an 8-Bit Arithmetic Logic Unit (ALU) with Verilog HDL. First, the basic functions that include logic and arithmetic are carefully designed and implemented in Verilog HDL to guarantee an easy and effortless integration into the 8-bit architecture. Simultaneously, an essential part of the design is the addition of a clock module which is designed to evaluate the validity of the output at the positive edge of every clock cycle. With the help of this unique feature, selecting operational modes can now be done automatically, simplifying the validation process and ensuring correctness and efficiency.

The approach also includes a thorough use of Xilinx tools for performing in-depth analysis of route delays and device utilisation. With careful resource allocation and the identification of any delays, this essential phase helps optimise the performance of the ALU and improves the architecture for increased efficiency. Furthermore, an FPGA platform is utilised to develop and simulate the Verilog HDL code. As a validation phase, this real-world deployment verifies the ALU's operation and performance metrics in actual hardware setting. By the use of this comprehensive methodology, the study provides a comprehensive knowledge of the architecture of the ALU, its interaction with the clock module, and its performance characteristics, providing insights into the practical application of the designed system.

2.1 Block Diagram

The functional components and interconnections of the 8-Bit ALU utilising Verilog HDL are shown in the block diagram. The logical and arithmetic operation modules for addition, subtraction, AND, OR, XOR, NAND,

NOR, and XNOR operations are clearly shown. It also has a clock and reset mechanism, which are essential for automating the assessment procedure. The input ports A and B, which each get 8-bit binary values, are shown in the diagram along with the ALU_Sel 3-bit select line, which indicates the operation to be performed.

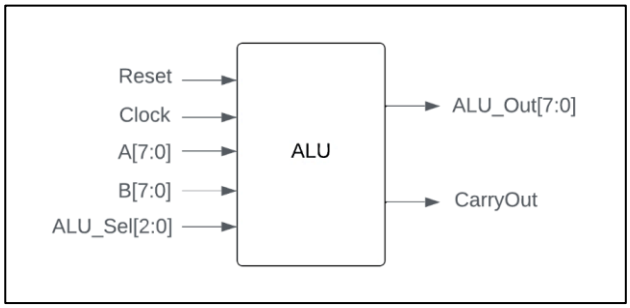

Fig.1 Block diagram of 8-Bit ALU

The 8-bit result is displayed on the output port, ALU_Out, and carry or borrow during operations is indicated on another port. The diagram illustrates which data and control signals go through the ALU, summarising its modes of operation without focusing on structural details.

2.2 Detailed Structure

The RTL (Register-Transfer Level) schematic of an 8-bit ALU using Verilog provides a detailed blueprint of the functional behavior of the ALU. This schematic is fundamental in describing how the ALU operates using a combination of digital logic gates, flip-flops, and interconnecting data paths. Each component in the RTL schematic plays a crucial role in the overall operation of the ALU, ensuring that it can perform a variety of arithmetic and logical operations efficiently.

The RTL schematic for an 8-bit ALU consists of a series of interconnected modules, each designed to perform a specific function. These modules include the Arithmetic Logic Unit (ALU) itself, a Control Unit, Input Registers, an Output Register, and a Carry Flag. Below is an expanded description of each module and its role within the ALU:

1. Arithmetic Logic Unit (ALU): The ALU is the main module that performs various arithmetic and logical operations like addition, subtraction, and bitwise manipulations on 8-bit inputs, producing an 8-bit output. It uses combinational logic and Verilog case statements for operation selection, ensuring high-speed single-cycle execution.
2. Control Unit: The Control Unit generates control signals that determine the ALU's operations based on input instructions. It uses a finite state machine (FSM) in Verilog to manage operation sequencing and data flow, ensuring the ALU performs the correct functions at the right time.
3. Input Registers: Input Registers temporarily hold 8-bit operands for the ALU, ensuring stable data transfer. Defined using reg or always blocks in Verilog, they are loaded with data on clock edges, facilitating seamless operation timing for the ALU.
4. Output Register: The Output Register stores the ALU's 8-bit results after each operation. Updated each clock cycle in Verilog, it holds the most recent computation results, making them available for further processing or output, ensuring data synchronization within the system.
5. Carry Flag: The Carry Flag indicates carry-out from arithmetic operations, crucial for detecting overflow. Implemented in Verilog with a logic statement, it updates alongside the Output Register to reflect the latest operation status, aiding in multi-byte arithmetic management.

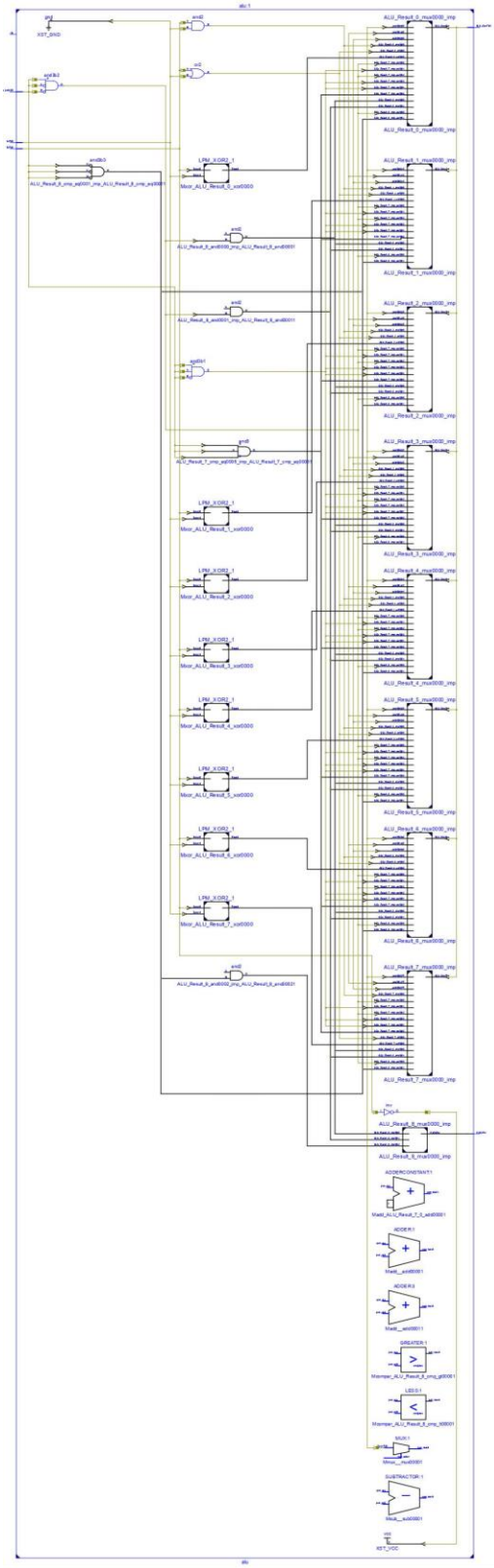

Fig. 2 RTL Schematic

3. Algorithm and Flowchart

Algorithm for ALU Module:

1. Start
2. Initialize Inputs and Outputs
   - Inputs: A, B, ALU_Sel, clk
   - Outputs: ALU_Out, CarryOut
3. ALU Operation (always block)
   - Check ALU_Sel value
   - Perform corresponding operation
     000: Addition
     001: Subtraction
     010: AND
     011: OR
     100: XOR
     101: XNOR
     110: NAND
     111: NOR
   - Set ALU_Result
   - Set CarryOut
4. Carry and Borrow Logic
   - Check ALU_Sel for 000 and 001
   - Set CarryOut or ALU_Result[8] accordingly
5. Clock Edge (posedge clk)
   - Increment count
6. Assign ALU_Result to ALU_Out
7. End

Algorithm for Test Bench Code:

1. Start
2. Initialize Inputs
   - A, B, ALU_Sel, clk
3. Simulation Loop
   - Repeat 8 times
   - For each ALU_Sel value (000 to 111)
   - Wait for 10 time units
4. End Simulation
5. Finish

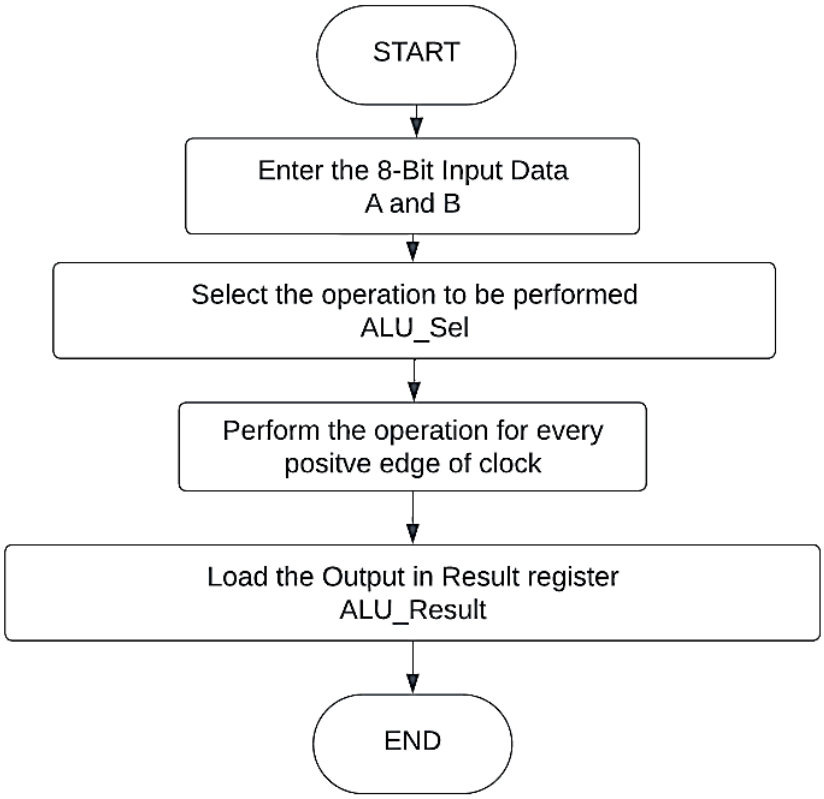

Fig. 3 Flowchart of 8-Bit ALU

4. Testing and Debugging

The testing was conducted on the FPGA Board - Spartan-3E XC3S250E. The UCF file was generated, in which the FPGA pins were allotted to input and output. After generating the bit file, the FPGA kit was connected to the laptop through a downloading cable with one end as a USB connector and the other as a JTAG connector. To dump the code, the Windows FPGA batch file was edited and run. Once the FPGA was loaded with the code, the LED next to the IC started blinking, indicating the status of the chip as programmed. The output was observed on the FPGA Board. Input was provided through the DIP switches, and the clock was varied using a trim pot available on the kit. The output was observed through the LEDs interfaced with the DIP switches.

During the testing of the ALU module, several troubleshooting operations were performed whenever the output was not as expected or errors were encountered. The main issue faced was during the implementation of the carry and borrow/signed logic, denoted by CarryOut. The addition of two numbers was not producing the CarryOut signal as expected due to logical errors in the implemented equation.

While implementing the borrow logic, the output did not match the calculations made on paper. These errors were resolved by cross-checking the logic of the equations and ensuring the output remained correct by implementing various test cases with different input values.

A counter was also implemented in the code. The results observed were as expected in the simulation waveforms, but due to some warnings generated in the code, the counter's operation on the FPGA kit was not functioning correctly.

The select lines were not incrementing on every clock edge pulse. As a result, the input for the ALU select lines had to be provided manually through the DIP switches available on the FPGA kit.

5. Results and Discussion

The findings from experimentation and thorough analysis that resulted from the Verilog HDL implementation of an 8-Bit ALU are discussed in the following section. It includes the assessment of the integrated clock mechanism's ability to independently confirm operating outputs, eliminating the need for manual selection of operations. Furthermore, in order to optimise the performance of the ALU, this part explores the insights obtained from Xilinx tools, specifically looking at device utilisation and route delays.

An additional fundamental component is the FPGA-based Verilog HDL code execution, which demonstrates the planned ALU's real-world applicability and practical validation according to hardware constraints.

5.1 Simulation Result

The synthesis and simulation of 8-Bit ALU Verilog module was executed on Xillinx Software.

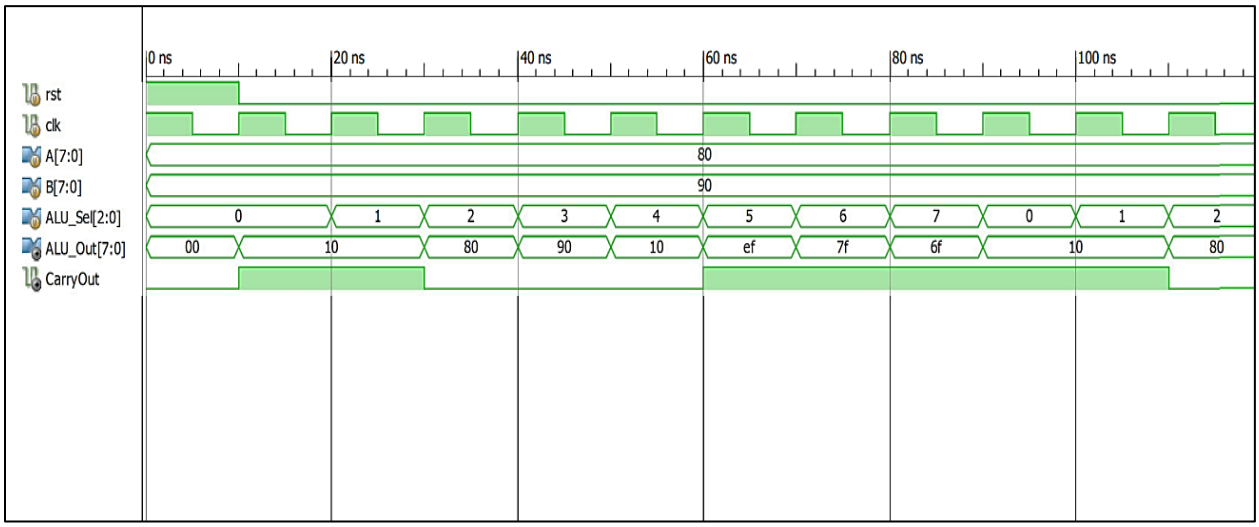

Fig. 4 Simulation result on Xillinx ISE

- The above simulation results are obtained through the execution of testbench code.
- A and B are the two inputs given to the ALU to check the output of the system.
- A is given value 80H and B is given the value 90H. (H denotes hexadecimal)
- The selection of inputs is made in such a way that the output will generate CarryOut signal in both addition and subtraction operation.
- The ALU select line is incremented every positive edge of clock cycle in order to display all the 8 operations of ALU.
- The outputs can be cross checked with the observation table.
- The carry out which is being generated during addition operation, is denoted by CarryOut signal as observed in waveform.
- The output of subtraction operation is a negative output and it is denoted by the high value of CarryOut signal.

5.2 Timing Summary

- Minimum period: 7.755ns (Maximum Frequency: 128.955MHz)
- Minimum input arrival time before clock: 11.271ns
- Maximum output required time after clock: 4.040ns

5.3 Observation Table

Table 1 Observation table

OBSERVATION TABLE				
Operands: A= 80H B=90H				
Sr. No.	ALU_Sel	Operation	ALU_Out	CarryOut
1)	000	Addition	10	1
2)	001	Subtraction	F0	1
3)	010	AND	80	0
4)	011	OR	90	0
5)	100	XOR	10	0
6)	101	XNOR	EF	0
7)	110	NAND	7F	0
8)	111	NOR	6F	0

5.4 Design Summary

Table 2 Device Utilization Summary

Parameters	Result
No. of Slices	49 (2%)
No. of Slice Flip Flops	14 (0%)
No. of 4 i/p LUTs	91(1%)

No. of I/Os	30
No. of bonded IOBs	30 (18%)
No. of GCLKs	1 (4%)

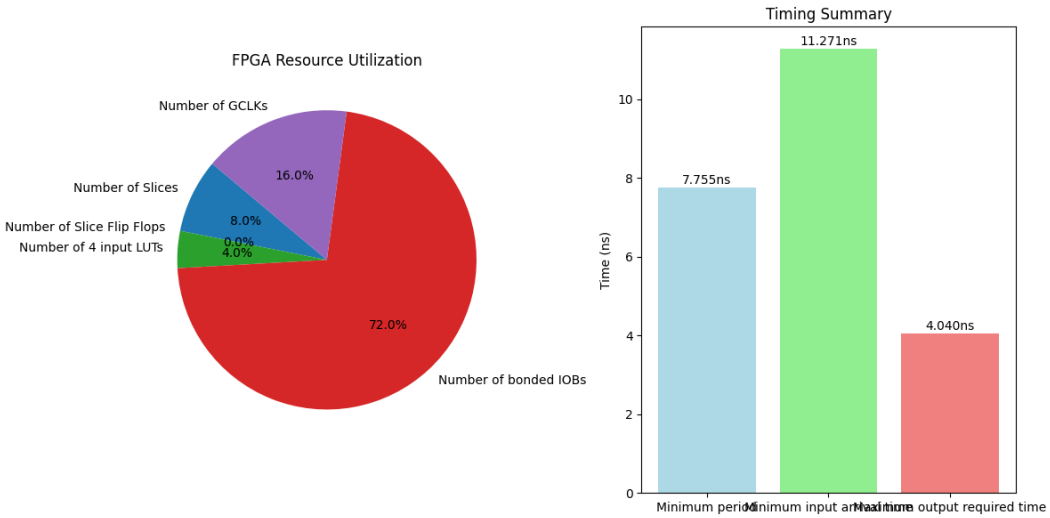

Fig. 5 - Evaluation Parameters

6. Conclusion

In conclusion, Verilog HDL's development and analysis of the 8-Bit Arithmetic Logic Unit (ALU), along with a synchronised clock mechanism for automatic output validation, represent an innovative approach in digital circuit design. The clock module's integration has been essential in eliminating the need for human interaction in choosing operating modes, which has streamlined the validation procedure and guaranteed accuracy at the positive edge of each clock cycle. Furthermore, an in-depth examination of device utilisation and route delays was made possible by the careful application of Xilinx tools, which improved the efficiency and resource allocation of the ALU. The robustness and practical application of the developed ALU are confirmed by the successful implementation and execution of the Verilog HDL code on an FPGA, confirming its operation in a hardware environment.

The use of Xilinx tools allowed for an in-depth analysis of the ALU's device utilization and route delays, resulting in optimized efficiency and resource management. Specifically, the timing summary reveals:

- A minimum period of 7.755ns, corresponding to a maximum operational frequency of 128.955MHz. This indicates that the ALU can handle high-speed operations efficiently.
- A minimum input arrival time before the clock of 11.271ns, ensuring that input signals are adequately prepared before the clock edge.
- A maximum output required time after the clock of 4.040ns, demonstrating that the outputs are stable and available within a short time frame after the clock edge.

The device utilization summary provides further insights into the ALU's efficiency:

- The ALU uses 49 slices, which is just 2% of the available slices, indicating a very low resource consumption.
- It utilizes 14 slice flip-flops, amounting to 0% of the available flip-flops, highlighting minimal usage of these components.
- The ALU employs 91 four-input LUTs, which is 1% of the total available, showcasing efficient use of logic resources.
- It requires 30 I/Os and 30 bonded IOBs, which is 18% of the available bonded IOBs, reflecting moderate usage of input/output pins.
- The ALU uses 1 GCLK, accounting for 4% of the available global clock resources, indicating efficient clock resource utilization.

The successful implementation and execution of the Verilog HDL code on an FPGA validate the ALU's operational robustness and practical applicability in a hardware environment. These calculated numerical parameters demonstrate that the ALU operates reliably and effectively within the specified constraints, confirming its capability to perform high-speed arithmetic and logic operations with minimal resource consumption.

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Optimization Techniques in Machine Learning and Deep Learning

Ashutosh.V.Patil [1], Gayatri.Y.Bhangle [2]

[1]Student, SCTR's Pune Institute of Computer Technology, Information Technology, Pune, Maharashtra, India
ashutoshpatil359@gmail.com
[2]Student, SCTR's Pune Institute of Computer Technology, Information Technology, Pune, Maharashtra, India
gayatribhangle18@gmail.com

Abstract

Optimization is an important part of machine learning and has attracted many research interests in this-field. As the amount of data continues to increase and the complexity of the model increases, optimization technology will face more challenges. Therefore, to solve these problems, this paper provides a reasonable analysis of different optimization methods in machine learning and deep learning. Here, we examine some methods such as gradient descent and their variants such as stochastic gradient, batch gradient, minibatch gradient, as well as advanced gradient methods such as power, RMSprop, Adam.
addition, we investigate evolutionary algorithms and Bayesian optimization as well as special techniques for training deep neural networks. By experimenting with and evaluating the effectiveness of various models, we demonstrate the advantages and limitations of each method and provide insight into the practical use of developing a good model.

1. Introduction

Machine learning[1] has fleetly advanced, getting a crucial research area and impacting colourful fields like translation, speech recognition[5], and image recommendation. At its core, machine learning relies heavily on optimization to minimize cost functions and tune model parameters from data. Maximization or Minimization is one of the fundamental pillars of machine learning [3].
The essence of most machine learning algorithms the most fundamental of machine learning is mathematical optimization, which deals with calculations of the parameters of a system designed to make decisions based on the information that is not available. This is now known to be the best choice for a given learning problem [6]. So, such success of optimization in ML has motivated extra-ordinary number of analysts and information researchers in various ranges to handle more profound challenges in machine learning issues and to plan the new algorithm or strategies which are broadly pertinent in these ranges.
As importance in optimization in machine learning and deep learning can be understood through three key aspects: (i) part in model performance (ii) effectiveness in training (iii) impact on modern operations. Similar in case it has different parameters like loss function, assigned weights, hyper parameters and other. So sometimes it can be also more challenging to the function which is defined for giving the optimized path or result for a corresponding function.[2]

Literature Survey

In [1], a study was conducted on various optimization methods used in training ML models. The study emphasizes the crucial role of optimization in fine-tuning hyperparameters to make less the error attribute, therefore enhancing the effectiveness and generalization. This paper discusses several enhancement strategies, including GD variants, η, DL problems and second order. Here principles, applications & advantages are outlined, with a focus on this applicability in overcoming challenges.
In [2], The paper titled "Optimization Algorithms for Machine Learning Models" explores various enhancement techniques used to enhance the efficiency of ML algorithms, specifically in predicting employee attrition. The study

covers several key optimization methods, including DL algorithms, clustering algorithm, normalizations and other GD's. Each algorithm's advantages, disadvantages, and implementation are discussed, with a attention on efficiency of correctness, speed and stability in the machine learning algorithms.

In [3], The paper titled "Optimization and plan of machine learning computational procedure for expectation of physical partition handle" presents the development with optimization of machine learning (ML) methods to predict and understand physical separation processes, specifically using adsorption for impurity removal from water. It achives high accuracy ($R^2 > 0.9$). The paper demonstrates that GB and ET models outperform RF, providing a robust approach for modelling adsorption with limited data.

In [4], The paper, "The Impact of Interdisciplinary Approaches on the Development of New Materials and Technologies", explores how interdisciplinary approaches, particularly the integration of materials science with other fields such as biology and engineering, have led to significant advancements in the development of new materials and technologies. The authors highlight the importance of collaborative efforts and the use of advanced computational techniques to design and optimize materials with novel properties.

In [5], "Overview of optimization calculations in cutting edge Neural systems", paper provides a comprehensive overview various algorithms used in NN focusing on 1st order, 2nd order and various IG methods. The authors classify and evaluate various optimization techniques, including Stochastic Gradient Descent (SGD), Adam, Quasi-Newton methods and more. The paper emphasizes on significance of these algorithms in improving the accuracy and efficiency of neural network training, particularly in challenging applications such as quantum computations and spiking neural networks.

2. Fundamentals of Optimization in machine Learning

Almost all machine learning algorithms can be designed as an optimization problem[1] for calculating minimum function value. Creating a model and creating a suitable role is the first step in the machine learning. After the objective function is created ,appropriate numbers or optimization tests are usually used to solve the problems to be solved. ML algorithms can be classified into supervised learning and unsupervised learning. So, below is the equation for the two types.

2.1. Supervised Learning Enhancement

In the directed approach , the objective was to discover the ideal mapping work f(x) to play down the error value of the preparing tests which are given to be as follows:

$$min_{\theta} \frac{1}{R} \sum_{i=0}^{r} G(y^i, f(x^i, \theta)) \qquad (1)$$

where R is the number of preparing tests work, x^i specifies point vector of the i_th tests, y^i is the comparing marker, and G down of error value[5].

2.2. Optimization of Unsupervised Learning

Clustering algorithms divides tests into multiple clusters pointing to play down contrasts between the tests within the same are one of kind from each other.[1][5] The k-means clustering calculate points to optimize the following low error function:

$$min_S + \sum_{d=1}^{d} \sum_{p \in S_d} \|x\text{-}\mu_d\| \qquad (2)$$

where:

d is the number of clusters, p is the include vector of tests, μd is the middle of cluster d, and Sd is the test set of cluster d

For a function $f(x)$ the gradient is:

$$\nabla f(x) = (\frac{\partial f}{\partial x1}, \frac{\partial f}{\partial x2}, \dots, \frac{\partial f}{\partial xn}) \qquad (2)$$

2.3. Formal Optimization Problem Statement: In machine learning, optimization problems emerge from the formulation of prediction and loss functions, which are encapsulated within the expected risk that the model seeks to minimize.[6]

As some of the algorithms in machine learning fails to train the deep neural networks so there the advance techniques originate. Again, let's look over the fundamental role of optimization in deep learning in short.

2.4. Training Deep Neural Networks

- **Objective Function:** In DL, optimization focuses on minimizing a low function that quantifies the mistake between anticipated and genuine values over potentially millions of parameters.

- **Complexity:** Deep neural networks have many layers and parameters, making the optimization problem highly complex. Effective optimization is crucial to ensure convergence and avoid issues like vanishing or exploding gradients. [6][2][5]

2.5. Gradient-Based Optimization

- **Algorithm Choices:** Advanced gradient-based optimization algorithms like Adam, RMSprop, and AdaGrad are essential for training deep learning models efficiently[6]. These methods adapt the learning rate and use past gradients to improve convergence.

- **Momentum and Adaptive Learning Rates:** Techniques like momentum and adaptive learning rates offer assistance speeding up training and improving the joining rate by adjusting the update rules based on past gradients[4].

2.6. Regularization and Generalization

- **Regularization:** Optimization also includes techniques[2] for regularization to prevent overfitting and enhance the model's capability to generalize to concealed information.

- **Hyper parameter Tuning:** Finding the best hyper parameters (e.g. learning rate, bunch size) through optimization procedures like search in grid or Bayesian optimization is crucial for enhancing the model's performance

2.7. System Overview:

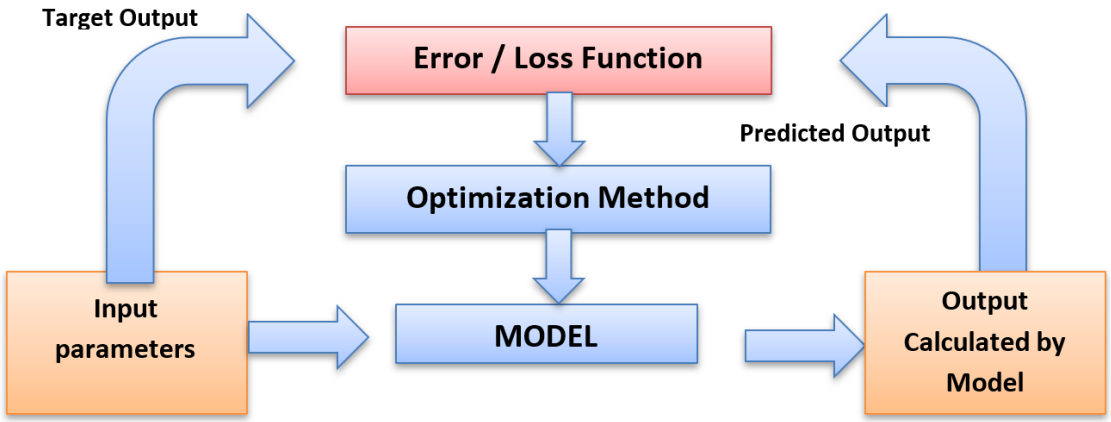

Fig. 1. Overall flow of the Optimization

3. Gradient optimization Techniques

3.1. Gradient Descent:

To model a problem efficiently, we aim to minimize cost, reduce computational power, and enhance performance. GD may be a crucial optimization algorithm utilized to discover the least of a function $f(x)$, significant in machine learning and Deep learning.[6][7][8] It works by iteratively adjusting parameters w to play down the less error function $J(w)$ which measures how well a model's predictions coordinate the real information. The objective is to play down this large cost function to progress model accuracy. Consider , a case of fitting a line to a set of data points using a linear equation: $\boldsymbol{y = mx + c}$ **where:**

- m is the incline of the line and c is the y-intercept

3.2. Challenges in line fitting

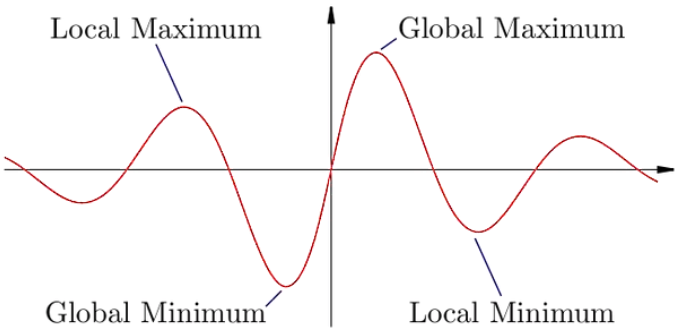

Fig. 2 Representation of Minima and Maxima

- **Global Minimum:**

The minima of global means where the cost function is at its absolute lowest across the entire domain. To find it, gradient descent iteratively adjusts parameters to minimize the cost function, though achieving this can be challenging with complex losses.[8]

Mathematical expression $for\ x = x_0$ to be at a global minimum could be:

$$f(x_0) \leq f(x)\ \forall\ x\ in\ entire\ domain$$

- **Local Minima:**

A local minimum is where the cost function is lower than at nearby points but may not be the lowest value across the entire domain. [8] This GD can meet to a nearby minima of local rather than the minima of global, particularly with complex functions.

Mathematical expression $for\ x = x_0$ to be at a global minimum could be:

$$f(x_0) \leq f(x)\ \forall\ x\ neighbourhood\ around\ x_0$$

- **Global Maxima:**

A global maximum is the highest point in a function's domain, with the function's value being the highest compared to all other points [6]. There can be one or multiple global maxima if the highest value is achieved at several points.

Mathematical expression $for\ x = x_0$ to be at a global minimum could be:

$$f(x_0) \geq f(x)\ \forall\ x\ in\ entire\ domain$$

- **Local Maxima:**

A local maximum is a point where the function's value is higher than at nearby points but not necessarily the highest value overall.

Mathematical expression $for\ x = x_0$ to be at a global minimum could be:

$$f(x_0) \geq f(x)\ \forall\ x\ neighbourhood\ around\ x_0$$

3.3. Derivation and formulation

We've covered the concepts of maxima and minima and their conditions. Now, let's derive the equations for $m\ and\ c$ the Gradient Descent Algorithm.[6][8] The general update for $y = ax + b$ formula in Gradient Descent is:

$$\theta = \theta - LR * \frac{\partial J(\theta)}{\partial \theta} \qquad (3)$$

For a parameter θ (which could be $a\ \ or\ b$) which defines the slope or intercept of a best fit line.

where:

- θ is the parameter being updated
- LR is the learning rate
- $\frac{\partial J(\theta)}{\partial \theta}$ is the angle gradient of the tests function J with regard to θ

- **Specific updates for m and c:**

$$a = a - LR * pd(a) \quad (4)$$

where:

- $pd(a)$ represents the fractional derivation of the tests function with regard to a, denoted as $\frac{\partial J}{\partial a}$

$$b = b - LR * pd(b) \quad (5)$$

where:

- $pd(b)$ represents the derivation of the tests function with regard to c, denoted as $\frac{\partial J}{\partial b}$

3.3.1. Interpretation

- **Gradient Calculation**: $pd(a)$ and $pd(b)$ are the gradients showing the direction and rate of change for each parameter.
- **Learning Rate:** LR controls the step size in the direction opposite the gradient. A small LR means slow convergence, while a large LR might overshoot.

3.3.2. After this the mean squared error is given as

$$MSE = \frac{1}{n}\sum_{n=1}^{n} \ ((r_i - (ax_i + \ b)))^2 \quad (6)$$

So, by comparing the equations 1,2,3 we calculate the partial derivative of $\frac{\partial J}{\partial a}$ and $\frac{\partial J}{\partial b}$. After formulating the equations,

$$pd(a) = \frac{-2}{q}\sum_{q=1}^{q} xii \ (r_i - (ax_i + \ g)) \quad (7)$$

$$pd(b) = \frac{-2}{p}\sum_{p=1}^{p} \ (r_i - (ax_i + \ g)) - 1 \quad (8)$$

Then you should update the parameters using chain rule :

$$w_1 = w_1 - LR * \frac{\partial}{\partial w_1} \quad (9)$$

$$w_2 = w_2 - LR * \frac{\partial}{\partial w_2} \quad (10)$$

Again for further calculation the steps could be:

- Define the values of x and y ii) Assume values of m and c iii) Calculate partial derivative of $J(m, c)$ iv) Update the parameters as

$$c_{new} = old - LR * \frac{\partial J}{\partial c} \text{ and similarly for } m \quad (11)$$

In Machine Learning, Gradient Descent has limitations, leading to the development of its variants. In the graph below, the arrow indicates where the function [8]starts decreasing in cost. By calculating the derivative, we observed that :

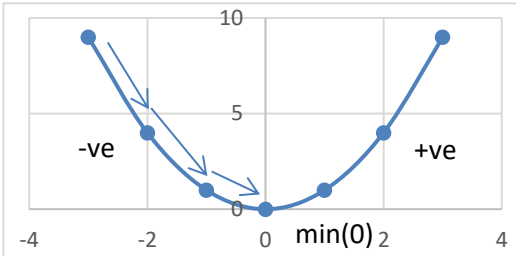

Fig. 3 Minimize the Loss function (x increases and f(x)decreases)

3.4. Limitations of Gradient Descent

- **High Computational Load:** Expensive and slow for large or high-dimensional datasets.
- **Memory Usage**: Requires a lot of memory to store and process large datasets.
- **Learning Rate Sensitivity**: Performance depends on the learning rate, which can affect convergence.

3.5. Types of Gradient Descent

3.5.1. Batch Gradient Descent

BGD calculates the steepest descent using the entire dataset, making it suitable for smaller datasets. It updates parameters based on this complete gradient computation. Batch Gradient Descent (BGD) [6][8]is a variant of the Gradient Descent optimization calculation utilized to discover the least of a error function. It's commonly employed in machine learning and DNN's to optimize the hyperparameters of a model. Similarly, name indicates the batch gradient it takes over a batch of samples to calculate the each of the training samples.

Given:

θ represents the parameters of the model, $J(\theta)$ is the cost function, α(alpha) is the learning rate

$$\theta = \theta - \alpha * \frac{1}{m} \sum_{n=1}^{n} \nabla_{\theta} J(\theta) \qquad (12)$$

here:

- m represents quantity of training examples
- $\nabla_{\theta} J(\theta)$ is the steepest of the cost function
- $J(\theta)$ with regard to the parameters θ

Limitations of Batch Gradient

- **Slow Convergence:** While working on large dataset, it can lead to slow processing.
- **Fixed Learning Rate & Not Suitable for Large Datasets:** A fixed learning rate may not suit all training stages, affecting convergence. High computational and memory demands.

It offers accurate gradient estimates and stable convergence, it can be computationally expensive [3]and memory-intensive, particularly for huge datasets. Variations like Mini-Batch Steepest Descent and progressed optimization calculations have been developed for addressing these limitations.

Algorithm 1. Batch Gradient Descent: Dataset features X, true labels y_{true}, number of epochs, learning rate η, Trained weights w, bias b

- Initialize w $\leftarrow$ 1, b $\leftarrow$ 0, n $\leftarrow$ number of samples in X
- d $\leftarrow$ number of features in X
    - Initialize empty lists for cost list and epoch list each epoch i from 1 to epochs

$$y_{predicted} = X * w + b \qquad (13)$$

    - compute the gradient for weights (w_grad and b_grad) using:

$$w_{grad} = -\frac{2}{total_{sum}} * X^T * (y_{true} - y_{predicted} \qquad (14)$$

$$b_{grad} = -\frac{2}{total_sum} * X^T * (y_{true} - y_{predicted}) \qquad (15)$$

- Update the weights

$$\mathrm{w} = w - learning_{rate} * w_{grad}$$

$$\mathrm{b} = b - learning_{rate} * b_{grad}$$

- i mod 20 = 0 Append cost to cost_list and i to epoch_list, w, b, cost,cost_list, epoch_list

    - Calculate the cost function :

$$\mathrm{cost} = \frac{1}{total_sum} * \sum(y_{true} - y_{predicted})^2 \qquad (16)$$

3.5.2. Stochastic Steepest Descent (GD)

Stochastic steepest model progresses a parameters more frequently by utilizing the single data point (or small subset) at a time, making it suitable for large datasets and online learning. It offers faster convergence and lower memory utilization compared to clumped slope descent(BGD).
Gradient Descent move towards the[9] minimum slowly.
.
Given:
To update Stochastic Gradient Descent use:

$$\theta = \theta - \alpha * \nabla_\theta J(\theta, x_i, y_i) \ (17)$$

where: $\nabla_\theta J(\theta, x_i, y_i)$ is the derivative of the function error $J(\theta)$ with regard to the parameters θ computed using single tests example[8] (x_i, y_i)

3.5.3. Limitations of Stochastic Gradient

- **Noisy Convergence:** Updates can be inconsistent, causing oscillations.
- **Hyperparameter Sensitivity:** Requires careful tuning of the learning curve.
- **Many Iterations:** May need many iterations to converge, leading to long training times.

SGD offers faster updates and lower memory usage but can suffer from noisy convergence and sensitivity to hyperparameters. [10] Mini-Batch SGD combines benefits of both SGD and Batch Gradient Descent to improve efficiency and stability.

Algorithm 2. Stochastic Gradient Descent: Dataset features X, true labels y_{true}, number of epochs, learning rate η, Trained weights w, bias b

- Initialize w $\leftarrow$ 1, b $\leftarrow$ 0, n $\leftarrow$ number of samples in X
- Initialize empty lists for cost list and epoch list
- each epoch i from 1 to epochs
    - Randomly pick a sample o f any_index from 0 to *overall samples*
    - $sample\ x \leftarrow X[any_index]$ $sample\ y \leftarrow y_{true}[any_index]$
      $y_{predicted} = Sample_x * w + b$
    - compute the gradient for weights (w_grad and b_grad) using:
      $w_{grad} = -2 * sample_x(y_{true} - y_{predicted})$
      $b_{grad} = -2 * (y_{true} - y_{predicted})$
- Update the weights
  $\mathrm{w} = w - learning_{rate} * w_{grad}$
  $\mathrm{b} = b - learning_{rate} * b_{grad}$
- i mod 100 = 0 Append cost to cost_list and i to epoch_list, w, b, cost,cost_list, epoch_list
- calculate the cost function
  $\mathrm{cost} = square * (y_{true} - y_{predicted})$

3.5.4. Mini-Batch Optimization

Mini-Batch slope plunge combines various aspects of BGD and SGD by utilizing little, arbitrarily chosen subsets of the preparing information (mini-batches) to upgrade model parameters[10].

Given:

- θ represents the hyperparameters of the model
- J(θ) is the cost function, α is a learning rate
- $\{(x_{i1}, y_{i1}) \ldots . (x_{ib}, y_{ib})\}$ is a mini-batch of training examples with size b

Updating Mini-Batch Gradient Descent can be done using following rule:

$$\theta = \theta - \alpha * \frac{1}{b} \sum_{j=1}^{b} \nabla_{\theta} J\left(\theta, x_{ij}, y_{ij}\right) \qquad (18)$$

where:

$\frac{1}{b} \sum_{j=1}^{b} \nabla_{\theta} J\left(\theta, x_{ij}, y_{ij}\right)$ is the gradient of the cost function computed over mini-batch.

3.5.5. Limitations of Mini-Batch Gradient

- **Hyperparameter Tuning:** The mini-batch size affects performance; too small or too large can impact results.
- **Local Minima:** Can still converge to local minima but is generally more stable than pure SGD..
- **Learning Rate Sensitivity:** Requires careful tuning of less η to fit it more in line.

Mini-Batch optimization[10] is a balanced approach that improves efficiency and stability compared to pure BGD or SGD, making suitable for huge data and deep learning models.

Algorithm 3. Mini-Batch Gradient Descent: Dataset features X, true labels y_{true}, number of epochs, learning rate η, Trained weights w, bias b

- Initialize w $\leftarrow$ 1, b $\leftarrow$ 0, n $\leftarrow$ number of samples in X
- Initialize empty lists for cost list and epoch list
    - each epoch *epoch* from 1 to epochs
      Shuffle X and y_{true} each mini-batch starting at *start* and ending at *end*
      $X\ batch \leftarrow X[start : end]$
      $$y_{predicted} = Sample_x * w + b$$
    - compute the gradient for weights (w_grad and b_grad) using:
      $$w_{grad} = -\frac{2}{len(y_{batch})} * X_{batch}^{T}(y_{batch} - y_{predicted})$$
      $$b_{grad} = -\frac{2}{len(y_{batch})} * X_{batch}^{T}(y_{batch} - y_{predicted})$$
- Update the weights
    - w $= w - learning_{rate} * w_{grad}$
    - b $= b - learning_{rate} * b_{grad}$
- i mod 10 = 0 Append cost to cost_list and i to epoch_list, w, b, cost,cost_list, epoch_list
- calculate the cost function

$$\text{cost} = \frac{1}{total_sum} * \sum(y_{true} - y_{predicted})^2 \quad (19)$$

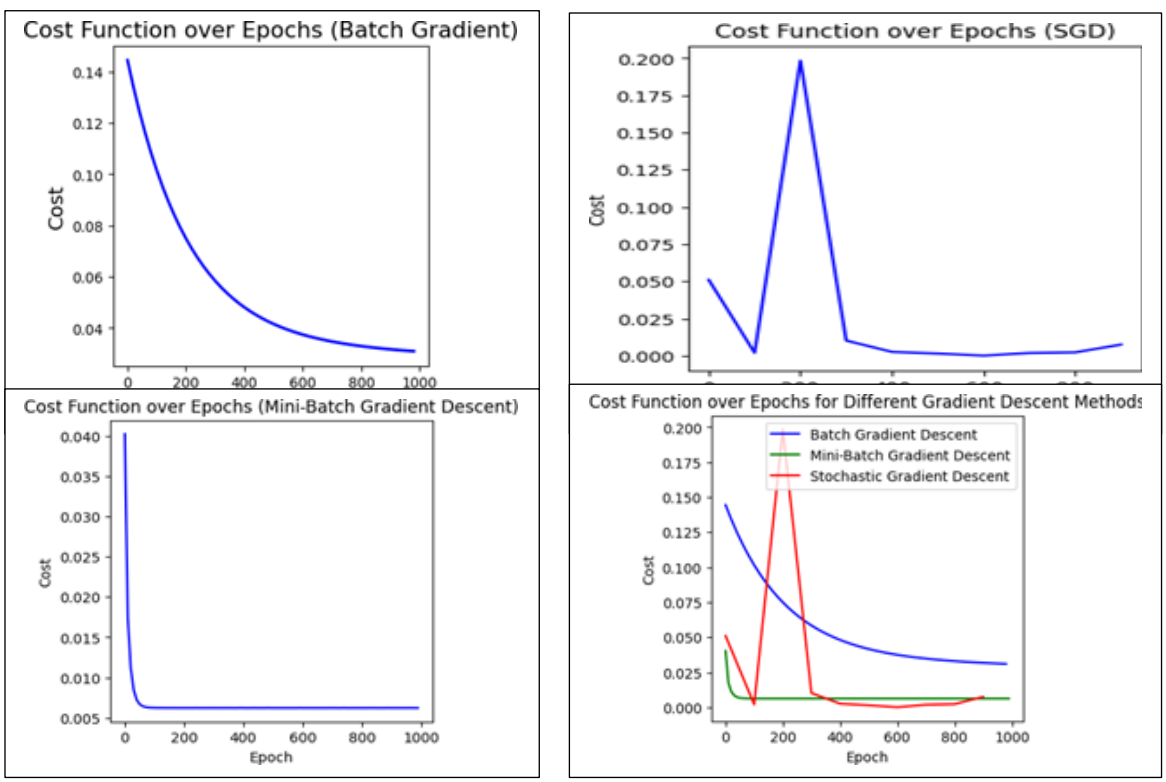

Fig. 4 Graphs Indicating their performance on the trained model Evaluation

4. Advance Gradient Algorithms

They address limitations such as noisy data and convergence issues by refining parameter updates, reducing the impact of outliers, and improving training stability.

4.1. Momentum:

Momentum accelerates gradient descent by combining the current gradient with a fraction of the previous update. This smooths out updates and helps navigate through areas with steep gradients, improving convergence[8][6].

Consider the following data points the time interval t and the weights b as follows [8]:

$t_1\, t_2\ \dots\dots\dots t_n$, $b_1\, b_2\ \dots\dots\dots b_n$

If the exponential moving average is applied to the time interval t_1 with the weight of b_1

$$\therefore V_1 = b_1 \qquad (20)$$

$$\therefore V_2 = \gamma * v_1 + b_2 \text{ (value of } \gamma\ 0 \leq \gamma \leq 1) \quad (21)$$

Substituting the value of V_1in equation (2) we get:

$$V_2 = \gamma * b_1 + b_2 \qquad (22)$$

Here the most priority is given to the $b_2\, followed\ by\ b_1$.,

Again for finding V_3 :

$$\therefore V_3 = \gamma * v_2 + b_3 \qquad (23)$$

Substituting the value of V_2in equation (ii) we get:

$$\therefore V_3 = \gamma\ (\gamma * v_1 + b_2\ ) + b_3$$

$$\therefore V_3 = \gamma^2 * b_1 + \gamma * b_2 + b_3$$

So now the final equation looks like:

$$\therefore V_3 = \gamma^2 * b_1 + \gamma * b_2 + b_3 \qquad (24)$$

The momentum can be applied with SGD to remove the remaining noise of the graph.

$$w_{new} = w_{old} - \eta * \frac{\partial L}{\partial w_{old}} \quad (25)$$

Applying the exponential weighted average the equation we get is:

$$w_{new} = w_{old} \left[\gamma * V_{t-1} + \eta * \frac{\partial L}{\partial w_{old}} \right] \qquad (26)$$

where V_{t-1} :

$$V_{t-1} = 1 * \left[\frac{\partial L}{\partial w_{old}}\right] t + \gamma * \left[\frac{\partial L}{\partial w_{old}}\right] t_{-1} + \gamma^2 * \left[\frac{\partial L}{\partial w_{old}}\right] t_{-3} \dots\dots n \qquad (27)$$

Algorithm 1. Momentum: Dataset features X, true labels y_{true}, number of epochs, learning rate η, Trained weights w, bias b, momentum μ

- Initialize w $\leftarrow$ 1, b $\leftarrow$ 0, $v_W \leftarrow 0$ (velocity for weights), $v_b \leftarrow 0$ (velocity for bias)
  $n \leftarrow$ number of samples in X
- Initialize empty lists for cost list and epoch list
  - each epoch from 1 to epochs
    $$y_{predicted} = X * w + b$$
  - Compute the gradient for weights (w_grad,b_grad) using:
    $$b_{grad} = -\frac{2}{total_{samples}} * \sum(y_{true} - y_{predicted}) \quad (28)$$
    $$w_{grad} = -\frac{2}{total_samples} * X_{batch}^{T} * (y_{batch} - y_{predicted})$$
- Update the velocity for weights and bias using:

$$V_w = momentum * V_w + learning_{rate} * w_{grad} \quad (29)$$
$$V_b = momentum * V_b + learning_{rate} * b_{grad} \quad (30)$$
$$w = w - V_w \qquad b = b - V_b$$

- i mod 10 = 0 Append cost to cost_list and i to epoch_list, w, b, cost,cost_list, epoch_list
- calculate the cost function as above

4.2. AdaGrad (Adaptive Gradient Algorithm)

Adaptive Steepest Descent [1][2] adjusts the η for each parameter independently based on past angles . Parameters with reliably huge angles of steepest get a less η , where those less steepest get bigger η [2]. The weight update formula is:

AdaGrad is:

$$w_{new} = w_{old} - \eta' * \frac{\partial L}{\partial w_{old}} \quad (31)$$

Now the values are clear so η' with respect to time t will be:

$$w_t = w_{t-1} - \eta'_t * \frac{\partial L}{\partial w_t} \quad (32)$$

where η'_t is given by,

$$\therefore \eta'_t = \frac{\eta}{\sqrt{\alpha_t} + \epsilon}$$

Here the value of the η is initial as 0.01 so as the learning rates will be get changed and the value of ϵ is any +ve number added to α_t to avoid a big error[4]. Now the α_t is given by:

$$\alpha_t = \sum_{i=1}^{t} \left(\frac{\partial L}{\partial w_i}\right)^2 \quad (33)$$

Similarly, as neural networks goes deeper so the $\alpha_t \uparrow$ increases and the learning rate $\eta \downarrow$ decreases.

AdaGrad's limitation is that it can grow very large over time, reducing the learning rate too much. To address this, variants like **AdaDelta** and **RMSprop** use a weighted average instead:

$$\therefore \eta_t' = \frac{\eta}{\sqrt{W_{avg_t}} + \epsilon} \quad (34)$$

Again the ϵ is the +ve number and the all-naming convention remains same as per the above AdaGrad algorithm. Where as the weighted average W_{avg_t} is given as:

$$W_{avg_t} = \gamma * W_{avg_{t-1}} + (1-\gamma) * \left(\frac{\partial L}{\partial w_t}\right)^2 \quad (35)$$

This approach prevents the learning rate from decreasing too quickly. Whereas in the case of W_{avg_t} we are restricting it for $\sum_{i=1}^{t}$ and the value of γ should be 0.95 in approximate cases. So, the value of W_{avg_t} will increase but not will get very-very high as α_t .

4.3. Adam Optimizer

Adam Optimizer combines the benefits of AdaGrad and RMSprop[8] by maintaining moving averages of both gradients and squared gradients.

4.3.1. Algorithm

i) Initially $V_{dw} = 0 \; and \; V_{db} = 0$ and $S_{dw} = 0 \; and \; S_{db} = 0$

$$w_t = w_{t-1} - \eta' * V_{dw} \quad , \quad b_t = w_{db\,t-1} - \eta' * V_{db}$$

$$\eta' = \frac{\eta}{\sqrt{S_{dw}} + \epsilon}$$

ii) On iteration on t inside epoch iii) Compute $\frac{\partial d}{dw}$ on current MBD

where $V_{dw} \; and \; V_{db}$ is given as:

$$V_{dw} = \beta V_{dw\,t-1} + (1-\beta) d_w * \frac{\partial L}{\partial w_{t-1}} \quad (36)$$

$$V_{db} = \beta V_{db\,t-1} + (1-\beta) d_w * \frac{\partial L}{\partial b_{t-1}} \quad (37)$$

So, now the weighted average parameters looks like as:

$$w = w - \eta * V_{dw}$$

$$b = b - \eta * V_{db}$$

So, this was the case with context of hierarchical learning to train DNN's.

Algorithm 2. Adam optimizer: Dataset features X, true labels y_{true}, number of epochs, learning rate η, β_1, β_2, ϵ, Trained weights w, bias b

- Initialize w ← 1, b ← 0, m_w ← 0 (biased first moment estimate for weights), m_b ← 0 (first moment for b), v_w ← 0 (raw 2nd moment for weights) v_b ← **0** (biased second raw moment estimate for bias), t ← **0** (time step)
- Initialize empty lists for cost list and epoch list
  - each epoch epoch from 1 to epochs t ← t+1

$$y_{predicted} = X * w + b$$

  - compute the gradient for weights (w_grad, b_grad) using:

$$w_{grad} = -\frac{2}{X.shape[0]} * X_{batch}^T * (y_{batch} - y_{predicted})$$

$$b_{grad} = -\frac{2}{X.shape[0]} * X_{batch}^T * (y_{batch} - y_{predicted})$$

  - Update the first moment estimate for weights (m_w, m_b) using:

$$m_w = \beta_1 * m_w + (1 - \beta_1) * w_{grad}$$

$$m_b = \beta_1 * m_b + (1 - \beta_1) * b_{grad}$$

  - Update Biased Second Raw Moment Estimate:

$$V_w = \beta_2 * V_w + (1 - \beta_2) * w_{grad}^2$$

$$V_b = \beta_2 * V_b + (1 - \beta_2) * b_{grad}^2$$

  - Compute Bias-Corrected Estimates: Compute the bias-corrected first moment estimate for weights (m_w_hat, m_b_hat) using:

$$m_b^{hat} = \frac{m_b}{1-\beta_1^t} \quad (38)$$

$$V_w^{hat} = \frac{V_w}{1-\beta_1^t} \text{ and } V_b^{hat} = \frac{V_b}{1-\beta_2^t} \quad (39)$$

- Update Weights and Bias:

$$w = w - \frac{\eta * m_w^{hat}}{\sqrt{V_w^{hat}} + \epsilon} \quad (40)$$

$$b = b - \frac{\eta * m_b^{hat}}{\sqrt{V_b^{hat}} + \epsilon} \quad (41)$$

- Compute Cost:

$$\text{cost} = -\frac{1}{X.shape[0]} * \sum (y_{true} - y_{predicted})^2$$

These were the Algorithms that were implemented on the Banglore_Housing_Dataset and the after the plotting of graphs we noticed the below results as:

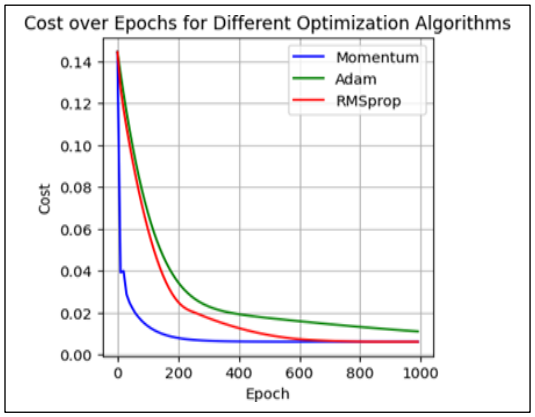

Fig. 5 Comparison of momentum vs Adam vs RMSprop

5. Second-Order Optimization

Second-Order Optimization methods improve upon first-order methods by incorporating insights of curvature regard of less error function, leading potentially faster convergence and better parameter updates. But they are computationally intensive. Approximation techniques help make these methods more practical for complex models[7][8].

5.1. Newton's Method

NM updates parameters using both the gradient and second order derivative matrix with loss equation, allowing the adaptive step sizes based on curvature[8][7].

Newton's Update Rule

Given a loss function L(θ) where θ are the parameters, NM updates parameters according below:

Compute Gradient:

$$\mathrm{g} = \nabla L(\theta)$$

where g is the slope vector belonging to loss equation.

Compute Hessian Matrix:

$$\mathrm{H} = \nabla^2 L(\theta)$$

where H is the second order derivative matrix and update parameters:

$$\theta_{t+1} = \theta_t - H^{-1}\mathrm{g}$$

Where: H is inverse of the second-order Jacobin matrix, and g is the slope vector.

5.2. Broyden-Fletcher-Goldfarb Shanno and Limited Memory bfgs

BFGS and L-BFGS are QN methods that approximate the second-order Jacobin matrix to optimize parameter updates, especially in high-dimensional problems[7].

5.2.1. BFGS (Broyden-Fletcher-Goldfarb-Shanno) algorithm

$$\theta_{k+1} = \theta_k - \alpha_k H^{-1} g_k \quad (42)$$

Where α_k is the step size.

Update Hessian Approximation: Update the inverse Hessian approximation H_{k+1}^{-1} using:

$$H_{k+1}^{-1} = H_k^{-1} + \frac{y_k y_k^T}{y_k^T s_k} - \frac{H_k^{-1} s_k s_k^T H_k^{-1}}{s_k^T H_k^{-1} s_k} \quad (43)$$

where $s_k = \theta_{k+1} - \theta_k \; and \; y_k = g_{k+1} - g_k$

5.2.2. L-BFGS (Limited-memory BFGS) algorithm

$$\theta_{k+1} = \theta_k - \alpha_k H^{-1} g_k \quad (44)$$

Update Approximation: Use the limited-memory approximation to update the inverse Hessian matrix. These were the Algorithms that were implemented on the Banglore_Housing_Dataset and the after the plotting of graphs we noticed the below results as:

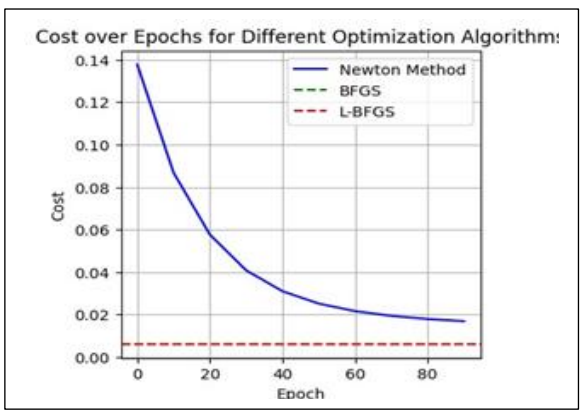

Fig. 6 Comparison of second order optimization

6 Evolutionary Algorithms

6.1 Evolutionary Algorithms Implementations

This technique leverages natural evolution principles to solve complex optimization problems. Evolutionary algorithms (EAs)[11] are probabilistic heuristics inspired by natural selection, where only the best-suited individuals survive and reproduce, iteratively guiding solutions toward an optimal or near-optimal outcome. Similar to Darwinian selection, inferior solutions are discarded, while superior ones evolve to form a new generation with the potential for improved performance..

6.2. Genetic Algorithm (GA):

The adaptive algorithms in DNN are progressive search methods inspired by natural selection. They use random searches and historical data to focus on promising solution areas[11][2]. GAs simulates "survival of the fittest" by evaluating and evolving a population of solutions each generation, with solution.

Algorithm 1. Genetic Algorithm: Optimization variables: Population, generations, mutation rates Hyperparameters: popoulas_size, formation in number, mutation frequency[8]

- Dataset with coordinates, population size, number of formations, mutation frequency
- Initialize *ga best values* as an empty list
  - Initialize *ga best values* as an empty list
  - Set population measures $\longleftarrow 20$
  - Set generations $\longleftarrow 100$
  - Set mutation freqn $\longleftarrow 0.1$
- Initialize population with $gf.sample(n = population\ size).to\ dict('records')$
  - each generation from 1 to generations
    - Initialize new population as an empty list and each of populace
    - Select guardian 1 utilizing selection(population, fitness)
    - Select guardian 2 utilizing selection(population, fitness)
- Make child utilizing crossover(both guardians)
  - Apply mutate(child, change rate)
  - Add child to unused population
  - individual$\leftarrow$ min(population, key = wellness) populace $\leftarrow$ sort new populous (measure-1)
- Append perfect value with its above equation
- Append fitness(perfect value) to *ga* perfect *values* best value

6.3. Particle swarm optimization (PSO)

Optimization seeks the best parameter values to meet design goals at minimal cost, used in many scientific fields[2]. Traditional algorithms often struggle with issues like local optima and unknown search spaces. To overcome these, metaheuristics like (PSO), (GWO), (ACO), (GA), and cuckoo search were developed. This article delves into PSO, building on the fundamentals of stochastic optimization[9][11]

6.3.1. Key Concepts:

- Particles: Individuals in the population, representing potential solutions.
- Position: A vector representing a particle's current state in the search space.
- Velocity: The rate of change of the loss position, guiding the movement.
- Best Solution(P_i): Better position of a particle has achieved largely.
- Global good solution (G_i): Good global positions achieved by some particle in PSO.

6.3.2. Overview of mathematics

- Every fragment in PSO has a related position, speed, wellness value.
- Each molecule keeps track of the bestFit, bestFitPosition.
- A record of global_best, Fit_position and global_best, Fit_value is kept up.

6.3.3. Mathematical Formulation

i. Velocity Update

To change the speed of each fragment, the equation formula is:

$$z_i\ (e+1) = \omega v_i(e) + c_i r_i(u_i - v_i) + \ c_2 r2(h - v_i)\ (45)$$

Components:

- $z_i(e)$: Current speed of element i at times t.
- ω: Inertia weight, balancing exploration and exploitation.
- c_1: Cognitive coefficient, representing the influence of the personal best position.
- r_1: Any number between 0 and 1, introducing randomness as the cognitive component.
- u_i: Owns best position of fragment *i*.
- v_i: Current position of particle iii.
- c_2: Social coefficient, representing the influence of the global best position.
- r_2: Random number between 0 and 1, introducing randomness in the social component.
- h: Denotes global best position found by the swarm.

ii. Position update equation

The position of each molecule is balanced utilizing:

$$v_i\ (e+1) = v_i\ (e) + z_i(e+1) \qquad (46)$$

This equation moves the particle to a new place belonging to its ongoing position and the updated velocity.

Algorithm 2: Particle Swarm Optimization: Optimization variables: Particle positions, velocities, best positions, global best position, Parameters: weight of inertia w, coefficient $c1$, sociol coefficient $c2$[8]

- Initialize the dataset with coordinates, number of particles, number of loops, inertia weight w, C.coefficient $c1$, S.coefficient $c2$ Global best position and value.
- Initialize pso *best values* as an empty list Class Particle :
  - Initialize ***position*** ← ***np.array*([*x, y*])**
- Initialize ***speed*** ← ***array*[*any uniform*(−1, 1), *any uniform*(−1, 1)]**
- Initialize *best* ***position*** ← ***position*** Initialize *best* ***value*** ← ***float*('*inf*')** Method
- update velocity (global best position):
  - Generate unique num r1, r2 ***cognitive*** ← ***c1*** · ***r1*** · (*best position*)
  - ***socio*** ← ***c2*** · ***r2*** · (*global best site*)
  - *speed* ← *w* · *speed* + *cognitive* + *social* Method update position():

    position ← ***position*** + ***speed***
- Load data from "tsp.csv" and initialize particles with coordinates
  - Initialize *global best* ***value*** ← ***float*('*inf*')**
  - Initialize *global best* ***position*** ← ***np.array*([0, 0])** **each** iteration from 1 to 100 each particle
  - Compute ***value*** ← ***objective*** *f* (*particle.position*) *value* < *particle.best value*

    Store the best value in best position with best global value with perfect global location
- Add g's best number to *pso better values global best place* , g's *value*

6.4. Differential Evolution (DE)

Mechanism: DE could be a population-based calculation algorithm. It optimizes a issue by repeatedly attempting to progress candidate arrangements based on a indicated degree of quality[4][2][8]. The key idea behind DE is the utilize of vector contrasts for perturbation of the population members, which helps to explore the search space efficiently.

Mechanism in Detail:

- Initialization: Each individual is represented as a vector x_i .
- Mutation:
  For each target vector x_i, a donor vector v_i is produced by including the weighted difference between two arbitrarily chosen populace vectors x_r2 and x_r3 by another randomly selected vector x_r1 [5][6]:

$$v_i = x_{r1} + F.(x_r2 - x_r3) \qquad (47)$$

- Crossover:
  The crossover operation mixes the target vector x_i and the giver vector v_i to shape a trial vector u_i. The components in trial vecs are determined as follows:

$$u_i[j] = \begin{cases} v_i[j] & if\ randj \le CR\ or\ j = j_{rand} \\ x_i[j] & otherwise \end{cases} \qquad (48)$$

  CR is the crossover probability, $rand_j$ is a uniformly distributed random number, and j_{rand} are arbitrary chosen num's that ensures only one element by donor vecs [2]

- Iteration:
  Steps 2 to 4 are repeated for a predetermined number of generations or until a satisfactory solution is found.

Algorithm 3: Differential Evolution: Optimization variables: Population, mutation factor, crossover rate, generations, Parameters: populace size, mutation element, crossover rating, number of components

- Dataset with coordinates, populace size, mutation element, crossover rates, number of components and the best solution
- Initialize de_best_values as an empty list
  - Set populace size ← 10
  - Set mutation element ← 0.8
  - Set crossover rating ← 0.7
  - Set components ← 100
  - Initialize population with $np.array([x,y])$ for coordinates from df
- Randomly sample population to size population size each generation from 1 to generations
- Initialize new population as an empty list each individual i in range(population size) Generate unique indices $a\ idx, b\ idx, c\ idx$ from population
  - $a,b,c \leftarrow population[a\ idx], population[b\ idx], population[c\ idx]$

- Mutation:
  - Compute $mutant\ vector \leftarrow a + mutation\ factor \cdot (b - c)$
- Crossover:

- Compute crossover vector by mixing mutant vector and population[i] crossover vector[j] ← mutant vector[j]
  if *random.random*() < *crossover rate* else *population*[*i*][*j*]

- Selection:
  - If *objective function*(*crossover vector*) < *objective function*(*population*[*i*])

- **THEN**
- Append crossover vector to new population , append population[i] for new poeple
- Update populace to new populace_int
  - Compute excellent solution ← *min*(*populace*, *key* = *objective function*)
  - Append objective function(best solution) to *de best values* best solution

---

7. Bayesian Optimization

Bayesian Optimization is a probabilistic method for optimizing complex, unknown functions with expensive evaluations, like hyper parameter tuning. It uses a surrogate show, regularly a Gaussian Process, to surmised the function and efficiently [8] guide the search toward optimal solutions with minimal evaluations.

7.1. Working

- Initial Sampling: Begin with a small set of objective function samples to train the surrogate model.
- Prediction: The surrogate model, using a Gaussian Process, predicts the mean (expected output) and variance (uncertainty) of the objective function at new input points.
- Acquisition equation: This work equalizations investigation for and exploitation (sampling high-performance areas)[8][8] to suggest the next evaluation point.
- Evaluation and Update: Evaluate error function with suggested calculation, update surrogate structure result with refine predictions.
- Iteration: Repeat the process, using the surrogate model to progressively zero in on the global optimum.

Acquisition Function: Balancing Exploration and Exploitation[8][11]

In Bayesian Optimization, the acquisition function guides the selection of the next evaluation point by balancing:

i. **Exploration**: Investigating areas of the search space with high model uncertainty to discover potential new solutions.
ii. **Exploitation**: Focusing on regions in surrogate framework calculates the large efficiency to refine best-known solution.[4]

Using predictions from the surrogate model, typically a gaussian-methods, the this indicates the forward point to make efficient, balancing these two objectives.

i. Expected Improvement

- **Concept:** EI predicts in gain over of current best solution by considering both the likelihood and magnitude of improvement.
- **Mathematical Explanation:** EI calculates the expected gain over the best-observed value using the surrogate model's mean and variance.
- **Balance:** EI balances exploration (uncertainty) and exploitation (potential improvement).

Formula:

$$EI(x) = E[maz(0, f(x] - f(x^*))] \qquad (49)$$

Where f(x) is predicted value at point x, and *f(x*)*[4] is good value.

ii. Probability of Improvement

PI aims in maximizing of probability for improving over the best-observed value.

Mathematical Explanation: PI calculates the probability that the objective function at a new point will outperform the best-known value, based on the surrogate model's prediction.
Balance: PI tends to favor exploitation more than exploration, especially if the threshold for improvement is set close to the best-observed value.
Formula:

$$PI(x) = \emptyset\left(\frac{\mu(x) - f(x*) - £}{\sigma(x)}\right) \quad (50)$$

where: $\mu(x)$ & $\sigma(x)$ are (predicted mean and S.D) at point x, *f(x*)* is the best-observed value, and $\emptyset$ is the total dissemination work of the standard typical conveyance. £ is a little parameter utilized to control the exploration-exploitation trade-off.

iii. Upper Confidence Bound (UCB)

Concept: UCB (Upper Confidence Bound) encourages exploration by focusing on areas with high uncertainty.

Mathematical Explanation: It selects points based on the predicted mean plus a multiple of the standard deviation, balancing exploration and exploitation.

Balance: The weight of the uncertainty term can be adjusted to favor exploration or exploitation. Formula:

$$UCB(x) = \mu(x) + k.\sigma(x) \quad (51)$$

Where $\mu(x)$ and $\sigma(x)$ are the predicted mean and standard deviation at point x, and k is a parameter that controls the exploration-exploitation trade-off.

7.2. Optimization Process

Bayesian Optimization is an iterative process that refines a surrogate model and selects new evaluation points based on an acquisition function:

- Initialization: Evaluate the objective function at initial points, often chosen randomly or via space-filling designs like Latin Hypercube Sampling[2][4], and fit an initial surrogate model (e.g., Gaussian Process).
- Surrogate Model Update: Update the surrogate model with new objective function evaluations to better estimate the function and its uncertainty.
- Acquisition Function Calculation: Compute the acquisition function using the updated model to balance exploration and exploitation.
- Termination: Stop when the criterion is reached and output the best solution found.

Algorithm 4: Bayesian Optimization : Number of restarts for acquisition function, number of iterations for optimization Bounds: Latitude and longitude ranges

---

- Dataset X_{sample}, Y_{sample} , Gaussian Process Regressor gpr, bounds, number of n iterations
- Initialize *bo_best_values* as an empty list
  - each iteration *i* from 1 to *n iteration*

- Fit gpr on X_{sample} and Y_{sample}

- Propose the next location to evaluate using $propose\ location(X_{sample}, Y_{sample}, gpr, bounds)$
  - $next\ sample \leftarrow propose\ location$ $next\ sample \leftarrow next\ sample.reshape(1, -1)$

- Obtain the objective function value for $next\ sample$
  - $next\ value \leftarrow objective\ function(next\ sample[0])$

- Update X_{sample} and Y_{sample} with $next\ sample$ and $next\ value$

- Track the best value found so far
  - $best\ index \leftarrow np.argmin(Y_{sample})$ Append $Y_{sample}[best\ index]$ to bo_best_values

- Compute $best\ solution \leftarrow X_{sample}[best\ index]$
- Compute $best\ value \leftarrow Y_{sample}[best\ index]$
- Print $best\ solution, best\ value$

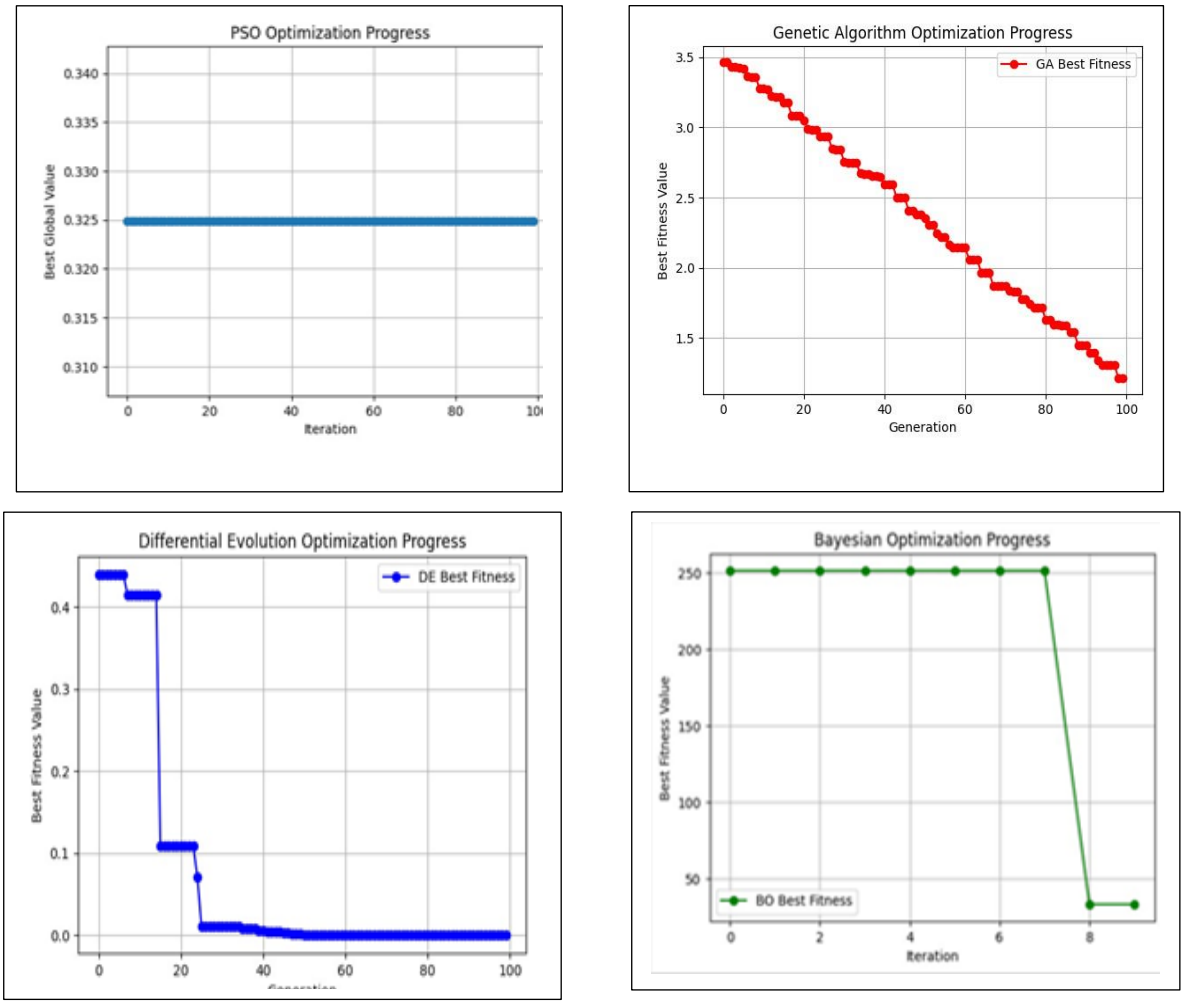

Fig. 7 Graphs Indicating their performance on the trained model Evaluation

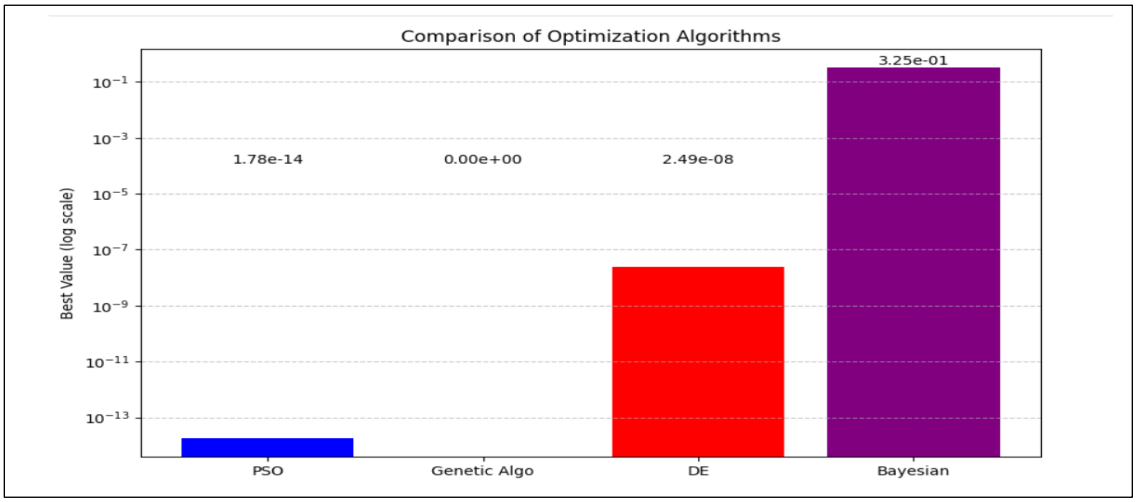

Fig. 8 Comparison of PSO , GA , DE , Bayesian optimizer

8. Challenges in Deep Learning Optimization

- **Non-Convexity:**
  Loss functions in deep learning are typically non-convex, with multiple local minima and saddle points. Unlike convex functions, where any local minimum is global, non-convex functions can have many zero-gradient points[11] that aren't optimal, making it challenging to find the global minimum and leading to potential local minima traps, especially in complex neural networks.
- **Vanishing/Exploding Gradients:**
  In deep neural networks, gradients can either vanish (slow learning with small updates) or explode (cause instability with large updates). This hinders training and may require careful initialization, normalization, or alternative architectures like ResNets.
- **High-Dimensional Spaces:**

  Deep learning models face slow and unpredictable convergence due to complex loss landscapes with many valleys and plateaus. The curse of dimensionality worsens this by exponentially increasing space volume and making gradients sparse and hard to interpret.

8.1. Regularization Techniques

Regularization[8] prevents overfitting by appending penalty to the error function, discouraging framework from exact fit too closely to training data. Known types are L1 and L2 regularization.

8.1.1. L1 Regularization (Lasso)

Definition: L1 regularization[6][8], too known as Lasso, include a large loss to the misfortune work that's relatively to the whole of the outright values of the framework parameters (weights).
Mathematical Formulation:
The model with L1 regularization can be stated as

$$Loss = Original\ Loss + \lambda \sum |w| \qquad (52)$$

where:

- w represents the framework parameters (weights),
- λ is the penalty term,
- $\sum |w|$ is whole of appropriate values of the weights.

Impact:
Encourages Sparsity: L1 regularization pushes some weights to zero, creating a sparse model.
Feature Selection: It helps identify important features by driving irrelevant weights to zero.

8.1.2. L2 Regularization (Ridge)

Definition: This regularization[6][8], too called as Ridge Regression, adds a large loss that is similar to whole of 2 of the frameowrks parameters (weights).
Mathematical Formulation:
Incase loss function, incorporating this, can be expressed as follows:

$$Loss = Original\ Loss + \lambda \sum |w^2| \qquad (53)$$

where:

w represents the hyperparameters (weights),
λ penalty term,
$\sum |w^2|$ is the sum of sqaures of the weights.

Impact:
Prevents Large Weights: Penalizes large weights, reducing model variance and improving generalization.
Smooth Solutions: Distributes weights more evenly across features, avoiding sparsity and including all features.

Note: For implementation codes please refer the below github links

- https://github.com/Gayuu03/Research
- https://github.com/bhak90-tesh/Optimization

The code has been implemented with the references to the above algorithms and [8][6][5] citations.

9. Results and Discussions

9.1. Dataset Description:

The dataset used in this analysis comprises information on residential properties in Bangalore, with a focus on three key attributes: area, number of bedrooms, and price. Area: This column represents the size of the property, measured in square feet It indicates a diverse range of property sizes from smaller units to larger homes. Bedrooms: This attribute indicates the number of bedrooms in the property. The dataset features properties with a varying number of bedrooms, from 1 to 6, Price: The price column denotes the cost of the property, expressed in lakhs of Indian Rupees (INR).

Link for dataset: https://www.kaggle.com/datasets/amitabhajoy/bengaluru-house-price-data

1) Gradient Descent Algorithms:

Table 1 Comparing MSE, MAE, R^2 of implemented algorithms

Optimization Algorithm	MSE	MAE	R^2
Batch Gradient	0.030	0.117	-1.085
Stochastic Gradient	0.014	0.078	0.004
Mini-Batch Gradient	0.006	0.044	0.578

- **MBD** is the best-performing algorithm all over the three, with the cheapest metrics and huge of third parameter from the table.

2) Advance Gradient Descent Algorithms:

Table 2 Comparing MSE, MAE, R^2 of implemented algorithms

Optimization Algorithm	MSE	MAE	R^2
Momentum Optimizer	0.006	0.043	0.578
Adam Optimizer	0.011	0.068	0.253
RMSprop Optimizer	0.006	0.043	0.579

- **RMSprop** is the best-performing algorithm among the three, with the lowest MSE and the highest R^2, although Momentum is very close in performance.

3) **Second Order Optimization Algorithms:**

Table 3 Comparing MSE, MAE, R^2 of implemented algorithms

Optimization Algorithm	MSE	MAE	R^2
Newton's Optimization	0.016	0.084	-0.095
BFGS Optimization	0.006	0.043	0.579
L-BFGS Optimization	0.006	0.043	0.579

- **BFGS and L-BFGS** is the best-performing algorithm among the three, with the lowest MSE and the highest R^2

So, here we can conclude that Mini-Batch GD, RMSprop and BFGS and L-BFGS are the best algorithms in their respective groups.

9.2. Dataset Description: The dataset used in this research is sourced from a file named tsp.csv. and contains geographical information, including latitude, longitude, and city names. The dataset contains 551 entries and 4 columns, with a mix of numeric and object (string) data types. Below is a summary of each column: Column 1: Contains numeric data (latitude coordinates), stored as float64. Column 2: Contains numeric data (longitude coordinates), stored as float64. Column 3 (City names): Contains string data representing city or location names. Column 4 (Unnamed: 3): Mostly contains null values, with only one non-null entry.

The Dataset was created by taking the latitude and longitude points from the google map with the help of Google_API.

1) Evolutionary Algorithms:

Table 4. Comparing the Best Value of implemented algorithms

Optimization Algorithm	Best Value	Mean Iterations to Best	Mean Best Value	Standard Dev. of Best Value
Particle Swarm Optimization	948.7	0.0	948.7	0.0
Genetic Algorithm	4.77	0.0	32.9	20.37
Differential Evolution	2.9	45.4	53.8	253.67
Bayesian Optimization	32.76	10	564.42	439.62

DE seems to be the best based on the best value and the closeness to the optimal solution, despite its higher variability and longer average iterations.

Overall, **Differential Evolution (DE)** appears to be the best choice given its extremely close best value to optimal. However, if consistency is critical, **PSO** might be preferred.

10 Conclusion:

This research provides a complete exploration of optimization strategies in ML, with a focus on their quantitative impact on model performance. Experiments were conducted across several optimization algorithms, evaluating their performance using various different key metrics. Among the gradient-based methods, Mini-Batch Gradient Descent demonstrated superior performance with an MSE of 0.006, an MAE of 0.044, and an R^2 of 0.578, outperforming both Batch and Stochastic Gradient Descent.

In advanced gradient descent algorithms, RMSprop stood out with an MSE of 0.006, an MAE of 0.043, and an R^2 of 0.579, closely followed by the Momentum Optimizer, which achieved nearly identical results.. When evaluating evolutionary algorithms, Differential Evolution (DE) emerged as the most effective, achieving a best value of 2.9, despite requiring an average of 45.4 iterations to reach this value. While Particle Swarm Optimization (PSO) provided a consistent best value of 948.7 with no variability, DE's proximity to the optimal solution makes it a preferable choice, especially when optimization accuracy is prioritized.

In summary, Mini-Batch Gradient Descent, RMSprop, and BFGS/L-BFGS were identified as the top-performing algorithms in their respective categories, demonstrating significant improvements in model accuracy and convergence speed. The study's results, supported by numerical performance evaluations, provide valuable insights for researchers and practitioners, contributing to the ongoing advancements over the fields of ML and DL.

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Website Coordination Team

Mr. Parag Jambhulkar
Assistant Prof.,
Dept. of Computer Engineering
PICT, Pune, India

Atharva Pardeshi
Full Stack Developer

Gayatri Sawant
Full Stack Developer

Rucha Rajmane
Full Stack Developer

Gaurav Waghmare
Full Stack Developer

Kshitij Dhake
Full Stack Developer

Atharva Dhake
Full Stack Developer

Ria Narode
Full Stack Developer

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www.pijet.org
pijet@pict.edu
020-24371101 (Ext-354)