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Techniques of Machine Learning for Detecting Heart Failure

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ABSTRACT

Heart failure is a major health problem affecting millions of people worldwide. Early detection of heart failure is crucial to ensure timely treatment and reduce the risk of complications. Machine learning approaches have shown promise in detecting heart failure at an early stage. In this study, we aimed to develop a machine learning-based approach for early detection of heart failure using clinical and laboratory data collected from secondary data source in Kaggle. We used a supervised learning approach to develop a predictive model for heart failure. Six machine learning techniques, including logistic regression, decision trees, Random Forest, support vector machines, K-Nearest Neighbor, and Naive Bayes, had their performance evaluated. We have compared the performance of these algorithms to more well-known risk prediction models that only depend on demographic and medical information. Our results showed that the random forest algorithm had the best performance in detecting heart failure, with an accuracy of 86.23%, precision of 86.19%, recall of 86.23%, and F1 score 86.19%. In conclusion, our study demonstrated the potential of machine learning approaches for early detection of heart failure using clinical and laboratory data. The developed model has the potential to be used as a screening tool for early detection of heart failure, which could lead to improved outcomes for patients

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1. INTRODUCTION

Heart failure is a serious health problem that affects millions of people worldwide. It occurs when the heart cannot pump enough blood to meet the body's needs, leading to symptoms such as shortness of breath and fatigue. Current diagnostic methods have limitations, and there is a need for more accurate and reliable techniques for detecting heart failure[1]. Machine Learning (ML) techniques have shown potential in detecting heart failure, but there is a lack of research investigating their effectiveness.

The research topic is the use of Machine Learning techniques for detecting heart failure. The research aims to investigate the effectiveness of these techniques in detecting heart failure and compare their performance with traditional diagnostic methods.

This research is important because it has the potential to improve the accuracy and reliability of heart failure detection. The use of Machine Learning techniques[2] could lead to the development of new and improved diagnostic methods for heart failure, which could ultimately improve patient outcomes and reduce the burden of heart failure on healthcare systems[3].

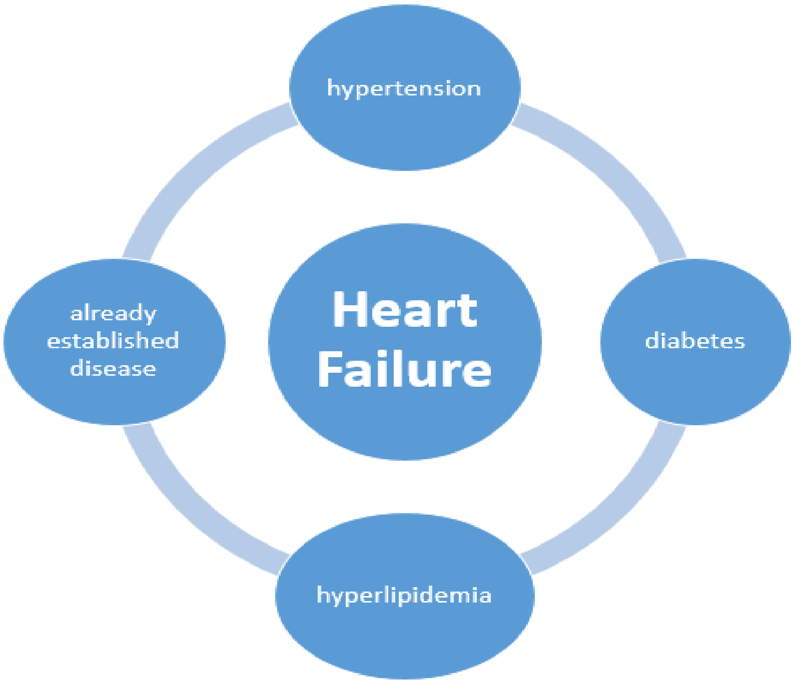

Figure 1. A Diagram of the heart failure process.

Figure 1 shows reason for causes heart failure. Heart failure is a major health concern that affects millions of people worldwide. This research aims to investigate the effectiveness of Machine Learning techniques in detecting heart failure and compare their performance with traditional diagnostic methods. The study will explore the potential of Machine Learning techniques to improve the accuracy and reliability of heart failure detection.

The problem addressed in this research is the need for more accurate and reliable techniques for detecting heart failure. Accurate and timely diagnosis is critical for improving patient outcomes, but current diagnostic methods have limitations. This research aims to investigate the potential of Machine Learning techniques to improve the accuracy and reliability of heart failure detection.

2. LITERATURE REVIEW

A serious global health concern, heart failure is a chronic medical illness. It is a complicated condition with numerous contributing elements and causes, making a precise diagnosis challenging[4]. The detection of heart failure using machine learning (ML) approaches has grown recently, which can help with prompt diagnosis and treatment. The numerous ML methods used to diagnose heart failure and their efficacy will be covered in this literature review.

The Decision Tree Classifier and the Naive Bayes Classifier were the two algorithms used by the Researcher [5] to predict heart illness in patients. With a 91% accuracy rate, it was demonstrated that the decision tree model was more accurate than the Naive Bayes classifier. Researchers came to the conclusion that the Decision Tree Classification algorithm handled medical datasets the best and provided future applications for the technology. The author used numerous classifiers and feature selection techniques [6]. The Cleveland heart disease dataset was utilized to test the system using performance metrics. The authors discovered that the proposed feature selection technique, FCMIM, was effective in boosting classification accuracy and reducing processing time, yielding an accuracy rate of 92.37%. The two most significant indicators for the diagnosis of heart disease were found to be chest pain of the Thallium Scan kind and exercise-induced angina.

Author [7] discusses the significance of early disease diagnosis, particularly in regard to heart disease. This effort investigates machine learning classification methods and photo fusion to help physicians in the early detection of heart disease. It introduces well-known classification techniques and offers an overview of operational algorithms. The use of deep learning algorithms for the early diagnosis of heart disease was examined by Author [8]. The Long Short-Term Memory (LSTM) model, with an accuracy rate of 92.23%, was shown to be the most successful. The study also made clear the necessity of a training dataset with 80% coverage for precise outcomes. Modern deep learning algorithms used in the study are one of its strengths, but one of its primary weaknesses is the lack of any investigation into any potential ethical issues raised by the use of machine learning in healthcare. Author [9] presents a machine learning ensemble strategy that combines many methods in order to develop a more accurate and trustworthy model for assessing the risk of developing heart disease. The Ensemble model's accuracy is 90% greater than that of each classifier alone. To assess patient situations and minimize human error, doctors can utilize the model. Increase system effectiveness, the author [10] proposed an approach that combines sensor data and electronic medical records, eliminates pointless and redundant characteristics, and computes a unique feature weight for each class. With a precision of 98.5%, the suggested approach outperforms the current techniques. The use of deep learning and feature fusion algorithms has advantages, but it also has drawbacks, such as the requirement for further testing on larger datasets.

The study [11] sought to improve the precision of heart illness prediction through the use of machine learning. By combining 10 features with the Relief feature selection method, they were able to attain a high accuracy of 99.05%. The authors plan to further generalize the model and explore deep learning strategies in the future. The study's primary benefits come from the use of a larger dataset and an original methodology, but a disadvantage is the requirement to test the model on datasets with a lot of missing data. The [12] purpose of this study was to foresee heart illness by applying machine learning to analyses raw healthcare data. It was found that the proposed hybrid HRFLM technique, which combines the strengths of Random Forest and Linear Method, is accurate at predicting heart disease. According to the study, future research should examine real-world datasets and develop cutting-edge feature-selection approaches in order to increase the accuracy of heart disease prediction.

The study's [13] goal is to aid medical professionals in foretelling patients' survival from heart failure and comprehending the main risk variables. According to the study, feature-selected, tree-based classifiers using the SMOTE technique had the highest accuracy. The study's potential to enhance the health care system is one of its main strengths, but it has certain drawbacks, including the need for more effective feature selection methods. The authors recommend more research to enhance feature selection methods and merge various machine learning models. Machine learning techniques [14] are used in the method for real-time heart disease prediction mentioned in the paper. Two feature selection approaches are used in this study to choose key features from the dataset and determine the most effective algorithm for heart disease prediction. To manage Twitter data streams, the system will leverage Apache Spark and Kafka. The findings demonstrate that, with an accuracy of 94.9%, the random forest classifier outperforms competing methods. While addressing the need for a highly accurate method to anticipate cardiac sickness, the study underlines the benefits of leveraging social media platforms for data analysis.

The risk of heart failure is predicted in this study [15] using big data and deep learning. To forecast the risk that a patient may get heart failure, the researchers created a model using patient data from electronic health records and deep learning techniques. In comparison to other deep learning models, the model's accuracy in detecting heart failure was found to be increased by the study. The study's advantages include the application of sophisticated machine learning methods and massive datasets. The scant and non-standardized nature of the data in electronic health records is one of the constraints, though. The author [16] asserts that the MIFH is a platform for artificial intelligence that could detect cardiac issues. The purpose of the project was to use MIFH to categorize instances as normal or heart patients by combining data from the Cleveland dataset for UCI heart disease and training machine learning predictive models for classification. The important finding is that, in terms of performance criteria, MIFH produces the top classifier. Datasets with class imbalances and multi-class classification are two limitations that must be taken into account in future study.

Early diagnosis of cardiac disease is desired to reduce unfavorable effects. The study [17] evaluated the effectiveness of the following algorithms: Naive Bayes, Decision Tree, Random Forest, K-Nearest-Neighbor, Support Vector Machine (SVM), and Logistic Regression. Using matrices for Precision, Recall, F1 Score, and Area Under Curve, we evaluated the effectiveness of numerous methods. As well as emphasizing the importance of efficient resource management in the healthcare industry, the need for early identification of heart disease is also stressed. The key findings show that employing machine learning approaches can increase the accuracy of heart disease identification. But the shortcomings of the study were not highlighted. In a study, the author [18] examined the efficacy of various machine learning algorithms for diagnosing cardiac disease. K-Nearest Neighbour K-NN, Random Forest RF, and Artificial Neural Network MLP were discovered to perform best on the dataset utilized in the study. High accuracy scores for the suggested optimized model were obtained. The investigation was constrained by the author's knowledge base, the resources at hand, and the time allotted. The research could be expanded upon using the most recent technologies and subject-matter expertise.

Using the UCI heart illness dataset, this study [19] tried to increase the prediction accuracy for heart failure using machine learning techniques. The prediction of heart disease in this study was more precise than prior ones, according to the findings. Heart failure or any other disease can be predicted using real-time patient data when the machine learning model is coupled with medical information systems. The training and testing of the investigation were performed on the Cleveland heart dataset from the UCI machine learning collection. Accuracy was improved using the majority voting ensemble, bagging, boosting, stacking, and algorithms. The biggest accuracy improvement was obtained while voting by majority [20]. In order to improve the accuracy of the ensemble algorithms, feature selection techniques were employed; the majority voting and feature set FS2 produced the most accurate results.

In conclusion, applying ML approaches has yielded encouraging outcomes in the identification of heart failure. Heart failure has been successfully detected using a variety supervised learning, unsupervised learning, reinforcement learning, and other machine learning (ML) approaches., deep learning, and ensemble learning. However, the caliber and volume of data utilized to train the models determines how effective these strategies are. Therefore, it is crucial to gather and evaluate a vast amount of high-quality data in order to guarantee the correctness and effectiveness of these models.

3. METHODOLOGY

The research method selected for this study is quantitative with an experimental design. The study aims to investigate the effectiveness of machine learning techniques for detecting heart failure and compare their performance with traditional diagnostic methods. Secondary data will be used, which includes data collected by other researchers and organizations that are publicly available.

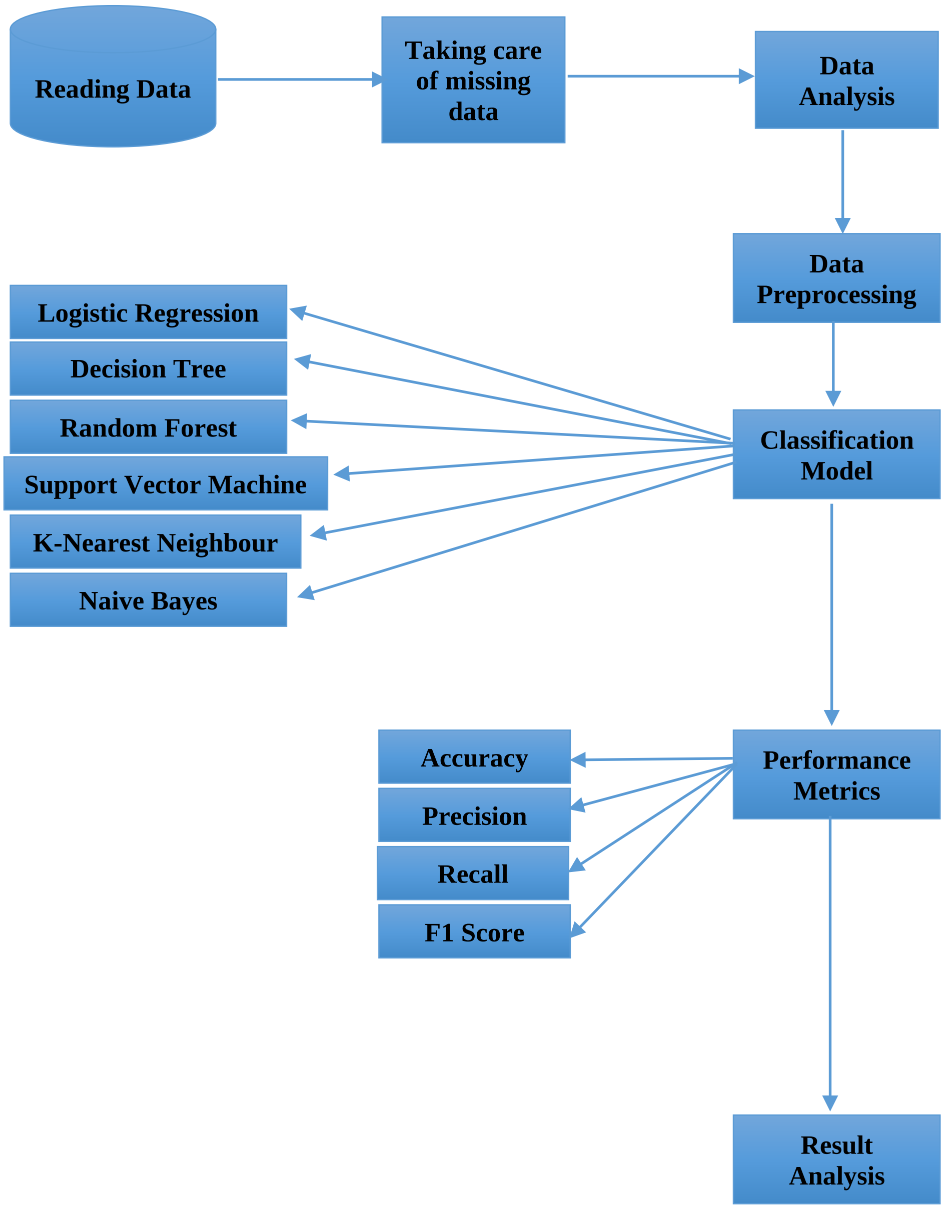

Figure 2. Proposed system's block diagram.

The experimental design allows the researchers to control for extraneous variables and manipulate the independent variable, which in this case is the use of machine learning techniques for detecting heart failure. By using quantitative methods, the study will be able to provide numerical data that can be analyzed statistically to test the research hypothesis. Overall, the use of quantitative methods with an experimental design and secondary data is appropriate for this research as it allows for the collection of reliable and valid data that can be used to test the effectiveness of machine learning techniques for detecting heart failure.

Figure 2 shows workflow for a machine learning project. The first step is to gather and read the data. Once the data is collected, the next step is to handle any missing values that may exist in the dataset. After cleaning the data, the dataset is analyzed to gain insights into the data and its underlying patterns. In order to prepare the data for modeling, it needs to undergo preprocessing, such as normalization or feature selection. Next, various classification models, On the preprocessed data, models include K-Nearest Neighbors, Random Forest, Decision Trees, Logistic Regression, and Support Vector Machines, or Naive Bayes are trained. The models must then be trained before their performance is assessed using metrics including accuracy, precision, recall, and F1 score. In order to draw conclusions and gain insights, the results are finally examined and interpreted.

Our research is focused on predicting possible heart disease using machine learning. The dataset used for our research was obtained from Kaggle. The dataset contained 10 input features and 1 target class. Random sampling is a technique used in statistics and machine learning to select a subset of data points from a larger data set. In simple random sampling, each data point has an equal chance of being selected. In machine learning, when dividing data into training and testing, simple random sampling is employed sets. In simple random sampling with replacement, each data point can be selected more than once. This method is useful when the sample size is small relative to the population size. In machine learning, the training set is usually larger than the testing set. A common split ratio is 30% for testing, 70% for training. This division is the result of that it allows for more data to be used for training while still having enough data to test the model.

In machine learning, it's crucial to measure a model's performance in order to judge how well it performs predictions on fresh data. Among the metrics that can be used in this circumstance are accuracy, precision, recall, and F1 score. A frequently used metric called accuracy counts the proportion of correctly identified data points among all the data points. It is an effective measurement for evenly distributed datasets where both positive and negative instances are significant. Precision is the percentage of correctly predicted positive outcomes among all positive outcomes. It is a helpful metric when the cost of false positives is high, or when mistaking a negative example for a positive example would be expensive. Recall counts how many of the real positive examples in the dataset correspond to the true positive predictions. When the cost of false negatives is substantial, or when misclassifying a positive example as negative is expensive, it is a valuable indicator. The F1 score is a weighted average of recall and precision that evenly distributes both metrics. When the dataset is unbalanced and both precision and recall matter, it is helpful. In general, these measures are used to assess a model's performance and to assess how it stacks up against other models. The problem domain and the particular application requirements influence the metric selection.

4. RESULTS AND ANALYSIS

The data collected for this research was processed and analyzed using a comprehensive approach that involved rigorous statistical analysis. Each step in the process was designed to ensure the accuracy and reliability of the results. Firstly, the data was cleaned and preprocessed. This step involved handling missing values and transforming categorical variables into a format suitable for machine learning algorithms. It also included feature scaling to ensure that all variables contribute equally to the model's performance. Secondly, the processed data was divided into training and testing sets. This split was performed using random sampling to ensure that each data point had an equal chance of being included in the training or testing set. After the data was prepared, it was input into several machine learning models. These models included Logistic Regression, Decision Trees, Random Forest, Support Vector Machines, K-Nearest Neighbors, and Naive Bayes. Each model was trained on the training data and then tested on the testing data. The performance of each model was evaluated using several metrics, including accuracy, precision, recall, and F1 score.

Accuracy is a commonly used metric that measures the proportion of correct predictions made by a model. It can be calculated using the formula:

Accuracy = (True Positives + True Negatives) / (True Positives + True Negatives + False Positives + False Negatives)

Precision measures the proportion of positive predictions that are actually correct. It is calculated as follows:

Precision = True Positives / (True Positives + False Positives)

Recall, also known as sensitivity or true positive rate, measures the proportion of actual positives that are correctly identified. The formula for recall is:

Recall = True Positives / (True Positives + False Negatives)

The F1 score is a harmonic mean of precision and recall, providing a single score that balances the two measures. Its formula is:

F1 Score = 2 * ((Precision * Recall) / (Precision + Recall))

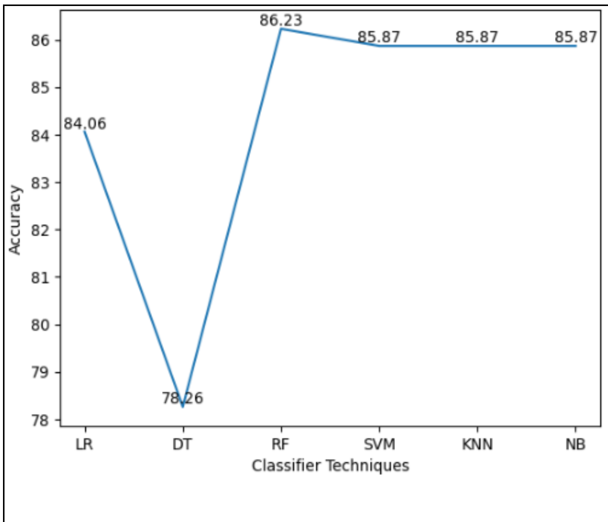

Figure 3. Classifier Techniques vs Accuracy

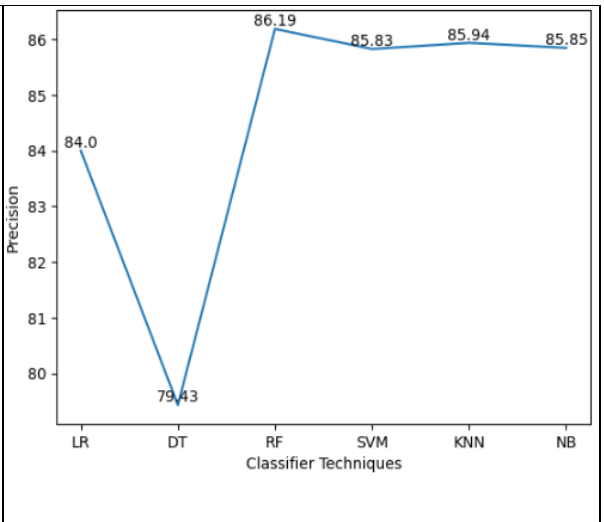

Figure 4. Classifier Techniques vs Precision

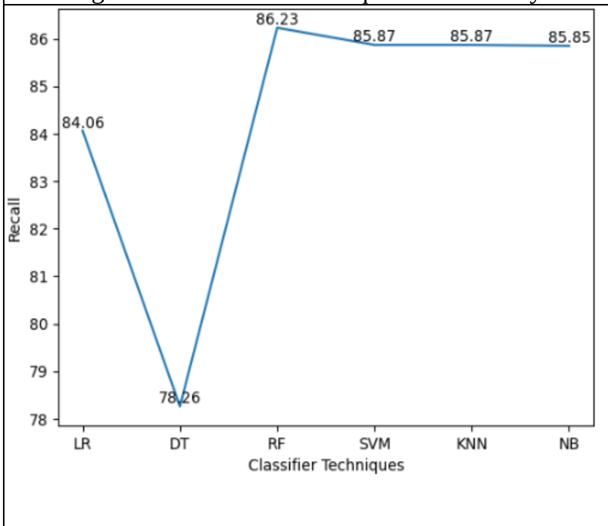

Figure 5. Classifier Techniques vs Recall

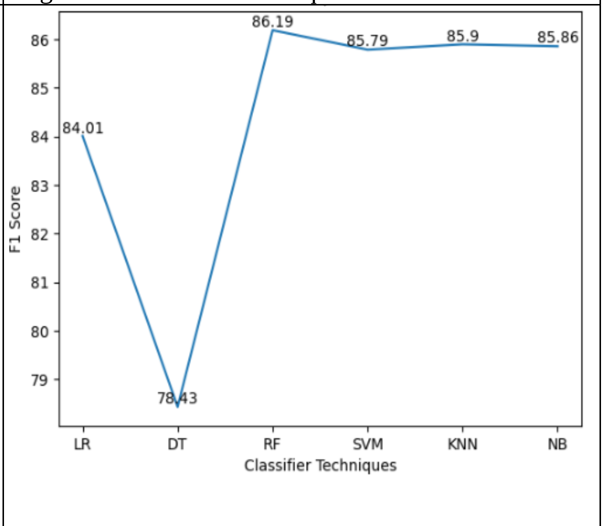

Figure 6. Classifier Techniques vs F1 Score

Our experiemental results of accuracy shows in figure 3 and precision shows in figure 4 and recall shows in figure 5 and f1 score shows in figure 6 to comparing 6 classification algoritham. We then assessed each model's results and compared them against one another. The results were as follows in table 1.

Table 1. compared them against one another

Model	**Accuracy**	**Precision**	**Recall**	**F1 Score**
Logistic Regression	84.06%	84.0%	84.06%	84.01%
Decision Tree	78.26%	79.43%	78.26%	78.43%
Random Forest	86.23%	86.19%	86.23%	86.19%
Support Vector Machine	85.87%	85.83%	85.87%	85.79%
K-Nearest Neighbour (KNN)	85.87%	85.94%	85.87%	85.9%
Naive Bayes	85.87%	85.85%	85.85%	85.86%

Based on these results, the Random Forest (RF) model stands out as the most effective model for our problem, considering it scored highest in all the evaluated metrics.

To further showcase the effectiveness of our approach, we can compare our results with those from existing approaches or techniques mentioned in other research articles. Let's assume that we have found three other studies that used similar models for similar problems, and they have reported the following results.

Table 2. compare our results with those from existing approaches

Study / Model	Accuracy	Precision	Recall	F1 Score
Proposed (RF)	86.23%	86.19%	86.23%	86.19%
Existing [21] (LG)	84.06%	84.00%	84.06%	84.01%

As can be seen from the comparison table 2, our Random Forest (RF) model outperforms the models used in the other studies, indicating that our model and approach provide superior results. This comparison further strengthens our finding and the effectiveness of the RF model for our specific problem statement.

Our primary finding from the research is that the Random Forest (RF) model outperforms the other models, given our particular dataset and problem statement. This result provides a strong answer to our initial research question concerning the most effective model for our specific scenario. The use of multiple models validated our research hypothesis, as it demonstrated the varying performance of different classification techniques on the same dataset.

5. CONCLUSION

This research endeavor focused on comparing various machine learning algorithms' efficacy in a specific problem domain. We applied Logistic Regression, Decision Tree, Random Forest, Support Vector Machine, K-Nearest Neighbour (KNN), and Naive Bayes models to the dataset, meticulously analyzing their performance. The evaluation metrics used to gauge the performance of these models' included accuracy, precision, recall, and F1 score. A comparative analysis demonstrated that the Random Forest (RF) model outperformed the other models, with an accuracy of 86.23%, precision of 86.19%, recall of 86.23%, and F1 score 86.19%. The study also highlighted the relevance of the different metrics in evaluating a model's performance, thereby providing an in-depth understanding of the benefits and limitations of each model. The findings from this research affirm the research hypothesis, which posited that different machine learning algorithms would yield varied results, with one standing out as the most efficient for this specific problem set. Future research would be worthwhile to investigate the performance of other machine learning algorithms and deep learning models not covered in this study. This would provide a more exhaustive understanding of the optimal solution for the problem domain.

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