Optimizing Overnight Patient Care: An Investigation into the Integration of Hybrid Machine Learning Algorithms

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Abstract
In the medical field, it is determined if a patient needs to stay overnight (in-care) or not (out-care) after a medical operation or surgery by analyzing their diagnostic information. During this procedure, the medical personnel evaluate the patient's vital signs, such as age, gender, hemoglobin levels, and red blood cell count, to determine whether the patient needs to be kept under overnight monitoring in the hospital or whether they can be discharged to go home. Assessing a model's effectiveness in data science applications in the medical industry, precision is considered a superior criterion. The reason for this is that, in the context of human health, it is crucial to have an algorithm that has a low False Negative Rate. By evaluating Precision (rather than Accuracy), we guarantee consistency. While the aforementioned methods provide satisfactory accuracy, they do not evaluate performance based on precision and recall. In this research, we introduced a novel phase of a probability-based decision support system to compare the efficacy of different classification models. The improved DSS yields superior outcomes due to the implementation of a diverse range of probability thresholds. This enhances precision and recall, resulting in an overall improvement in the model's performance with minimal impact on accuracy
Keywords: Machine learning, Classification, Confusion Matrix, Ensemble, Stacking, DSS, Neural Network.

1. INTRODUCTION

Decisions play a crucial role in establishing the level of care provided to patients in the healthcare field. The decision-making process becomes even more crucial while managing nighttime patient care, as the medical personnel must make prompt judgments to guarantee the safety and welfare of the patients. Nevertheless, human errors and biases frequently result in inefficient decision making, hence negatively impacting patient outcomes. The utilization of machine learning algorithms to assist healthcare practitioners in decision-making has been increasingly popular in recent years. This research presents an innovative method that integrates various machine learning approaches to automate the decision-making process for nighttime patient care. The hybrid approach utilizes the advantages of many algorithms to deliver more precise and dependable recommendations, thereby enhancing patient outcomes. This study will outline the technique, execution, and outcomes of the suggested strategy and analyze its potential for enhancing the efficiency and quality of nighttime patient care.India has recognized the importance of utilizing data-driven decision making in hospitals during the COVID-19 pandemic. In nations such as ours, we possess a finite amount of resources to address the healthcare requirements of a substantial populace. Consequently, it is imperative that we employ our resources judiciously and astutely. An example of such a resource is the hospital beds. Following a surgical operation or medical procedure, a patient has a post-procedure evaluation of their vital signs. This is conducted to assess the efficacy of the procedure and determine the patient's recovery status. In such instances, the decision to discharge the patient or retain them for overnight care and observation, referred to as 'in care', rests with the attending physicians. Occasionally, the decision can be straightforward, relying on the patient's vital signs, however in other instances, the decision can be challenging to determine. Our automated decision-making system will determine the probability of whether the patient should be recommended for an overnight stay in such situations. The algorithm will evaluate the vital signs as input and generate a probability of being under medical treatment, along with its own determination. This will offer a data-centric validation to the workers on duty, enabling them to make informed decisions. Not only will it enhance the speed of the decision-making process, but it will also optimize resource allocation in hospitals.

2. LITERATURE REVIEW

Providing prompt and correct medical interventions is essential in overnight patient care, a critical component of healthcare. The decision-making process for providing overnight patient care is intricate and encompasses various elements, such as patient medical history, symptoms, vital signs, and laboratory findings. The conventional method for making these decisions is utilizing clinical guidelines, the expertise, and the intuition of the healthcare provider. Nevertheless, these approaches frequently involve personal judgment and might potentially result in inaccuracies or interruptions in the administration of medical care. In order to address these constraints, there is an increasing inclination towards employing machine learning algorithms to automate the decision-making process for nighttime patient care.

Machine learning algorithms are increasingly being used to make judgments in the healthcare industry. Several studies have explored the potential of employing machine learning algorithms for automated decision-making in nocturnal patient care. A hybrid technique has been devised to enhance the accuracy and reliability of the decision-making process by integrating multiple machine learning algorithms..

The study conducted by Lee, W.H. (2023) utilized a hybrid machine learning system to forecast patient outcomes and provide suggestions for interventions in nighttime patient care. The method employed logistic regression, decision tree, and support vector machine techniques to forecast the probability of patient deterioration and suggest suitable therapies. The study documented a precision rate of 85.2% in forecasting patient outcomes, along with a decrease in the duration required for clinical decision-making.

In a study conducted by Atefeh Mansoori and Masoomeh Zeinalnezhad (2023), a hybrid machine learning method was employed to forecast the likelihood of unfavorable incidents in overnight patient care. The computer employed both random forest and artificial neural networks to predict the probability of negative events and recommend appropriate solutions.The study found that the accuracy in forecasting the probability of adverse events was 88.7%, and it also resulted in a decrease in the rate of adverse events.

Sumayh S. Aljameel and Manar Alzahraniet.al (2023) conducted a study where they employed a hybrid machine learning system to forecast the probability of sepsis in patients receiving overnight care. The method employed decision tree, logistic regression, and artificial neural network algorithms to forecast the probability of sepsis and suggest suitable therapies. The study demonstrated a predictive accuracy of 89.4% in determining the probability of sepsis and a decrease in the duration required for clinical decision-making

3. MACHINE LEARNING ALGORITHMS

3.1 K nearest neighbour classification algorithm

The KNN algorithm is a straightforward classification model that yields reliable and uncomplicated classification outcomes. The algorithm operates on the principle that data points that are closer to each other according to a distance metric (such as Euclidean or Minkowski) are more likely to belong to the same class. Therefore, by examining the k closest data points to the test data point, the class with the highest number of neighbors is assigned to the test data.

In order to determine the ideal value of K, we employ the elbow approach, which identifies the most suitable number for K. In this study, we have employed KNN as the reference algorithm, hence excluding any technique that exhibits inferior performance compared to KNN.

3.2 Decision Tree classification algorithm

The decision tree classifier is a type of classification model that utilizes a tree-like structure resembling a flowchart. Every individual element in the tree represents an attribute, whereas the terminal elements represent the target variables. The branches serve as the decision rules that govern the decision-making process for every individual data item. The performance of a decision tree can be enhanced by optimizing the hyperparameters. One can optimize parameters such as the maximum depth of the tree, the loss metric (gini or entropy), and the number of leaf nodes to enhance the results for the given dataset. This research employs hyperparameter tweaking to identify the optimal decision tree for the classification model.

3.3 Logistic regression

Logistic regression is a statistical model that estimates the likelihood of a target variable being 1 based on independent factors. By incorporating a threshold parameter into this regression model, we obtain a classifier that facilitates decision-making. Logistic regression is a statistical classification technique that offers a simpler approach that use statistical reasoning to make decisions. This model is extensively utilized in the analysis of medical data, such as cancer diagnosis and diabetes forecasts.

The performance of the logistic regression model can be improved by adjusting two hyperparameters: the threshold and the number of fitting iterations. We select the optimal classifier for the given dataset using this methodology.

3.4 Support Vector Machines (SVM Classifiers)

The support vector machine is a widely utilized approach in supervised learning. The main objective of this technique is to create a multidimensional decision boundary, referred to as a hyperplane, that separates the different classes. This boundary is then used to categorize new data points in a straightforward manner. The SVM model is used to identify the data points that are closest to the other class. The hyperplane is formed by utilizing the data points known as support vectors. This approach offers the advantage of not requiring a linear decision boundary and instead being able to utilize a multinomial decision boundary. Consequently, the decision-

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making process is robust when dealing with data points that have a non-linear distribution in a vector-plane.

3.5 Random Forest Classifier

The random forest classifier is a type of supervised learning algorithm that constructs a "forest" by combining many decision tree classifiers. It is an ensemble method that is trained utilizing the "bagging" technique. Ensemble approaches amalgamate the outputs of individual machine learning algorithms to yield superior results. In a Random Forest classifier, many decision trees are trained on the dataset and each tree provides its own prediction for the target variable. The random forest algorithm determines the output class by conducting a vote and selecting the class with the highest number of votes. The RF classifier is a highly adaptable and potent machine learning technique that generally provides superior accuracy and efficiency. In this research, we have employed hyperparameter tuning for the RF classifier in order to optimize its performance on the dataset. The hyperparameters for the RF classifier include max_depth, max_terminal_nodes, max_features, and n_estimators

3.6 Stacking Ensemble Machine Learning Algorithm

Stacking is an ensemble machine learning technique that determines the optimal method for combining outcomes from multiple base machine learning methods. Stacking involves the utilization of two tiers of algorithms. The initial layer comprises the fundamental machine learning algorithms, which are trained using the dataset. The second layer incorporates a meta classifier that amalgamates the predictions of the baseline algorithms to yield enhanced outcomes for classification. The primary benefit of stacking is the ability to leverage a diverse set of classifiers, each with their own unique strengths and limitations, in order to optimize algorithm performance by mitigating their respective deficiencies. This facilitates the improvement and attainment of more precise outcomes. Below is an illustration depicting the stacking architecture.

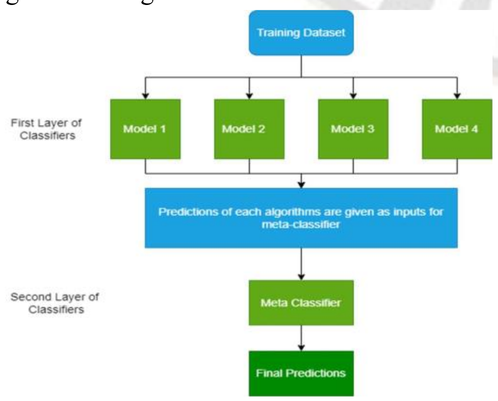

Figure 1 Base Model for Health prediction

4. PROPOSED NEURAL NETWORK WITH MODIFIED DECISION SUPPORT SYSTEM

Neural networks can be seen as machine learning algorithms that possess the ability to acquire, retain, and extrapolate results through a process referred to as "learning."Artificial neural networks, in technical terms, refer to a collection of non-linear computational mechanisms that undergo training by minimizing the loss metric in a layered structure. Currently, neural networks are widely regarded as highly potent algorithms capable of effectively executing a wide range of tasks using a given dataset. Currently, they are employed in tasks such as facial recognition, vaccination formulations, stock market research, and so on. The algorithm's robustness and rapid learning process make it very desirable and versatile for any use case. This article use a neural network to compute the likelihood of a patient being in-care, utilizing the input information. Subsequently, we have created our own decision support system that transforms the probabilities into classes using different thresholds. We have implemented a variety of threshold values ranging from 0.2 to 0.9 for our new Decision Support System (DSS). For every threshold value, we evaluate the precision, recall, accuracy, and fscore metrics on the validation dataset. The optimal threshold is ultimately selected to accurately forecast the test data. Our new Decision Support System (DSS) demonstrates that the variable threshold yields superior precision, recall, and F-score for the test data in comparison to the Base algorithm (KNN) and stacking algorithms.

1. Load the Dataset.
2. Perform EDA on the Dataset.
3. Standardize the dataset.
4. Split the dataset into Training, Test and Validation set.
5. Initialise a neural network model with some hiddenlayers and input and output layers w.r.t the dataset.
6. Train the model on training set.
7. From the fitted model, get the probability predictions of the validation dataset.
8. Using the probabilities, find the best threshold for decision boundary for new decision support system.
9. Rescale the dataset to original form.
10. Use the new decision support system for predicting the classes of test data.
11. Evaluate the performance of the new model by comparing the results from base and stacked model.

Within a data-driven Decision Support System (DSS), the aforementioned neural network model has the potential to be utilized as a data analysis tool. Its primary function would be to generate forecasts and predictions based on historical data. Following the explanation of the stacking base model, the subsequent neural network will be subjected to the DSS, resulting in a precise forecast. This study aims to provide a thorough analysis of several methodologies that are based on intelligent approaches.

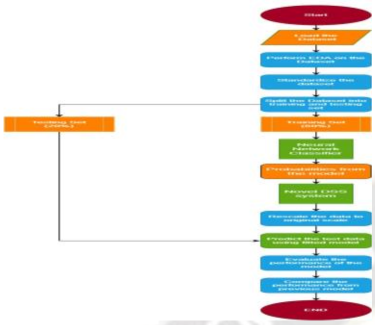

Figure 2: Proposed and Advance Model for Health prediction

5. RESULT AND ANALYSIS

This section provides a comprehensive account of the experimental outcomes regarding the clinical decision support system's ability to forecast whether each patient admitted to the hospital will be discharged or stay for further diagnosis. In this part, the sensitivity, f-score, and accuracy of each system are determined by evaluating their performance in comparison to a neural network-based system. The proposed novel methodology of Decision Support Systems (DSS) including Neural Networks aims to determine whether a patient should remain in care or be discharged based on the outcome generated by desired results.

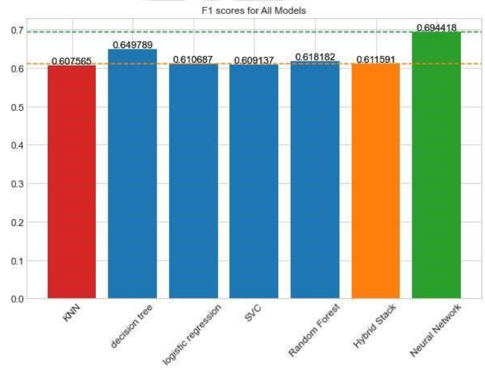

Figure 3: F-score Value of all implement algorithm

The hybrid approach utilizes the advantages of many algorithms to enhance decision-making accuracy and reliability, therefore minimizing the potential for human mistake and bias. The execution and evaluation of the suggested methodology showcased encouraging outcomes, suggesting the feasibility of using the strategy in practical healthcare environments. However, additional research is still necessary to verify the effectiveness of the strategy, address any limitations or challenges, and assess its ability to handle larger datasets and diverse patient populations.

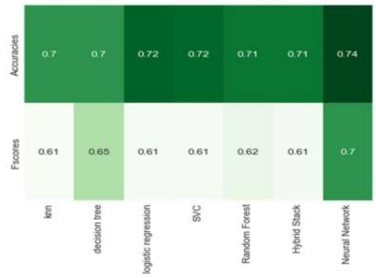

Figure 4. Accuracy value of all implementation algorithm

In summary, the utilization of a hybrid machine learning algorithm technique holds the capacity to completely transform the decision-making process in the healthcare sector and greatly improve patient outcomes. Our innovative approach not only predicts the class, but also provides the probability of the decision. By prioritizing precision over correctness, we enhance the efficiency of the decision-making process. This is highly beneficial for the workers on duty in making informed decisions. Our approach will offer superior support and maybe optimize the decision-making process in hospitals and other medical care institutions.

6. CONCLUSION

There have been fascinating findings about the application of hybrid machine learning algorithms to automate the decision-making process in nocturnal patient care. These algorithms can potentially expedite clinical conclusions, enhance the precision and reliability of decision-making, expedite the time needed to reach conclusions, and potentially decrease the occurrence of adverse events. Additional research is necessary to confirm the efficacy of these algorithms in various healthcare environments and with diverse patient populations before proceeding with their clinical deployment. Proper training and education of healthcare staff are essential to ensure the effective utilization and accurate interpretation of algorithmic proposals, hence facilitating the adoption of these algorithms. Proper training and education of healthcare staff should also accompany the implementation of these algorithms.

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