IMPROVING HEART DISEASE DETECTION AND PREDICTION THROUGH DEEP AND MACHINE LEARNING ALGORITHMS IN COMPUTED TOMOGRAPHY (CT) IMAGERY

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ABSTRACT
The aim of this study is to investigate the effectiveness of deep and machine learning algorithms for detecting and predicting heart disease using CT imagery in Malawi, and to compare their performance with traditional methods. The study involves data collection and pre-processing, model development and testing, and comparison of the performance of various algorithms. Through this study, to gain a better understanding of the strengths and limitations of deep and machine learning algorithms in this critical medical application.

Keywords: Deep learning algorithm, CT imagery, Heart disease, Medical imaging, Diagnosis, Machine learning algorithms

INTRODUCTION

Heart disease is a global health concern affecting millions of people. Early detection and diagnosis are critical for effective treatment and prevention of complications. Deep learning and machine learning algorithms present a promising approach for heart disease detection. The proposed system for heart disease detection utilizes CT imagery in resource-limited settings, where access to specialized diagnostic tools and expertise is limited. The system allows doctors and healthcare professionals to upload CT scans, which are then prepared and analyzed using deep and machine learning algorithms to identify potential signs of coronary artery disease. The resulting report provides relevant findings to support informed decision- making about patient care. This system has the potential to be an effective diagnostic tool in the fight against heart disease.

1. To evaluate and compare the performance of deep and machine learning algorithms in thedetection and prediction of heart disease using CT imagery.
2. To identify the algorithm with the highest prediction and detection rate for diagnosingheart disease using CT imagery and present an outline of its performance.

In recent years, deep learning algorithms have been gaining attention in the medical field for their ability to accurately detect complex patterns and structures in medical images, such as CT scans [2]. Studies have shown that deep learning algorithms, particularly Convolutional Neural Networks (CNNs), can accurately identify abnormalities and lesions in CT images, such as lung nodules [4] and breast cancer [5]. CNNs provide more detailed feature extraction from images and automatically classify features for better identification, resulting in high levels of accuracy for detecting and predicting heart disease using CT imagery [6].

In addition to deep learning, machine learning techniques have also been used for heart disease prediction [8][26]. Machine learning allows algorithms to learn from data and improve their performance over time, making it well-suited for predicting heart disease by identifying patterns and trends in large and complex datasets. A study using a decision tree-based algorithm showed better performance in predicting heart disease than logistic regression and artificial neural networks [3][21]. Further research has since been conducted to develop more sophisticated machine learning algorithms, such as the use of support vector machines (SVMs) and KNN [10]. These methods hold great promise for improving the detection and prevention of heart disease, but their performance can vary depending on factors such as dataset quality, specific techniques used, and algorithm parameters[22]. Therefore, continued research is needed to fully understand and develop more effective algorithms for heart disease prediction [8].

THEORETICAL FRAMEWORK

The artificial intelligence (AI) theoretical framework for heart disease prediction and detection has been widely studied in the literature. These frameworks typically involve the use of machine and deep learning techniques, such as neural networks [11], to develop predictive models for heart disease[20]. This is the key theoretical approach. One popular approach under the AI framework is the use of convolutional neural networks (CNNs) [11] for image classification and feature extraction from medical images, such as CT or MRI scans[23]. Overall, AI-based theoretical frameworks have demonstrated promising results in the literature for heart disease prediction and detection [12] and have the potential to improve the diagnosis and treatment of heart disease[18].

Model building phase where one or more deep and machine learning algorithms are trained on pre-processed data and the best-performing algorithm is selected using cross-validation[24][25]. Three algorithms for the model application selected are Support Vector Machine (SVM) [13],Random Forests, and Convolutional Neural Networks (CNNs) [14,15,16]. CNN is a popular algorithm for deep learning [19][27].

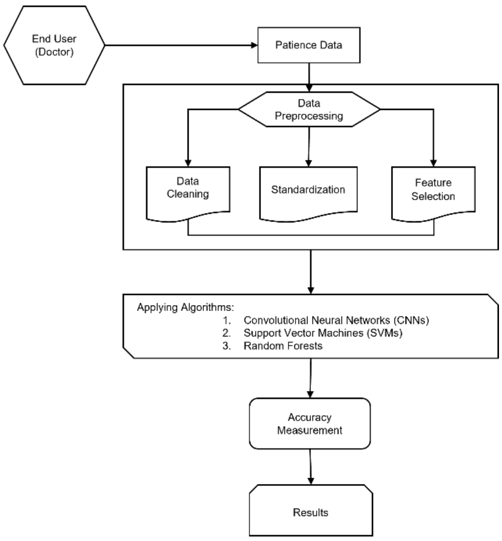

Fig.1: Proposed System Architecture

In the literature, there has been considerable research into the use of artificial intelligence (AI) frameworks to predict and detect heart disease. These frameworks often rely on machine and deep learning techniques, such as neural networks [11], to develop predictive models for heart disease. A popular AI approach is to use convolutional neural networks (CNNs) [11] for feature extraction and image classification in medical images, such as CT or MRI scans. The effectiveness of these AI-based frameworks has shown promise in the literature for improving the diagnosis and treatment of heart disease [12].

During the model building phase, one or more deep and machine learning algorithms are trained on preprocessed data, and the best-performing algorithm is selected using cross- validation. Three algorithms selected for the application of the model are Support Vector Machine (SVM) [13], Random Forests, and Convolutional Neural Networks (CNNs) [14,15,16]. Among these algorithms, CNNs are a popular choice for deep learning.

METHODOLOGY DATA COLLECTION

The research method of choice was the quantitative approach. The CT imagery heart dataset was obtained from the Kaggle.com repository. The data was utilised to test the model for heart disease detection and prediction using the algorithms. The key dataset characteristics were the two groups of images, which were images with and without heart disease. The images were provided in two folders train and test.

DATA STANDARDIZATION

Data was standardised using image processing techniques to resize and normalize the images, ensuring they were consistent in size and resolution (refer to Figure 2). Additionally, the system checked for any errors or inconsistencies in the images to ensure high-quality data suitable for analysis.

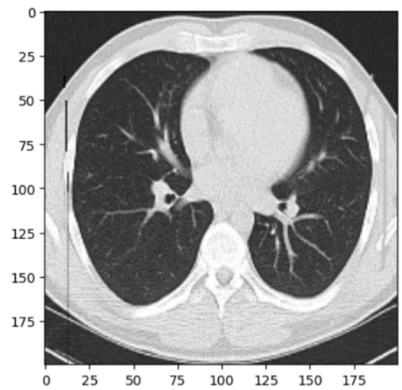

Fig 2: Visualising matplot data

To train and test the Random Forest, SVM, and CNN algorithms on the CT imagery heart dataset, the following steps were taken using Python:

- **Data preprocessing:** The dataset was loaded and preprocessed using image processing techniques to standardize the images' size and resolution.
- **Feature extraction:** The key features were extracted from the images to improve the algorithms' performance.
- **Model training:** The preprocessed data was used to train the machine learning algorithms, which included the Random Forest and SVM algorithms.
- **Model selection:** The algorithms were evaluated using cross-validation, and the best-performing algorithm was selected.
- **Hyperparameter tuning:** The selected algorithm's hyperparameters were optimizedto obtain the best performance.
- **Model testing:** The selected algorithm was used to make predictions on the testdataset,

and its performance was evaluated.

- **Evaluation metrics:** The algorithms' performance was evaluated using accuracy, precision, recall, and F1-score metrics.

1. Dataset and split it into training and testing sets.
2. Train a Random Forest model on the training set.
3. Train an SVM model on the training set.
4. Train a CNN model on the training set.
5. Evaluate the performance of both models using accuracy, sensitivity, precision, specificity, confusion matrix, and ROC curves.

By following these steps, high levels of accuracy were achieved for the detection and prediction of heart disease using the CT imagery dataset.

Random Forest Model

The Random Forest algorithm is a machine learning technique that employs multiple decision trees to construct a more reliable and precise model. It operates by selecting a random subset of features and constructing several decision trees based on these features. The final prediction is made by combining the predictions of all these trees. Compared to a single decision tree, the Random Forest algorithm is less prone to overfitting, which is a significant advantage.

For this study, a Random Forest model with a maximum depth of 5 will be trained, and the testing set will be used to predict the target variable. The performance of the model will be assessed using accuracy, sensitivity, precision, specificity, confusion matrix, and ROC curves, which can be seen in Fig.3

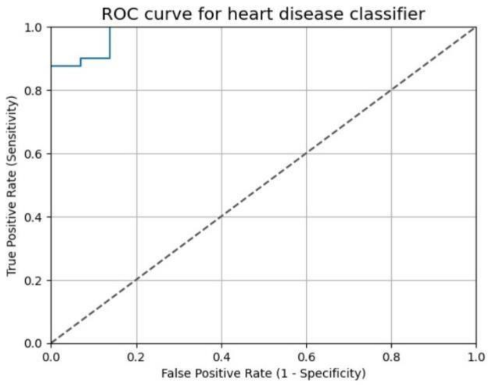

Fig.3: ROC curve for heart disease classifier

Support Vector Machine Model

The SVM algorithm is a discriminative model that separates data points using a hyperplane. The algorithm works by finding the hyperplane that maximizes the margin between the two classes. The SVM algorithm has the advantage of being effective in high-dimensional spaces and being less prone to overfitting than other models. In this analysis, we will train an SVM model using a linear kernel. We will then use the model to predict the target variable of the testing set. We evaluated the performance of the model using accuracy, sensitivity, precision, specificity, confusion matrix, and ROC curves.

CNN (Convolutional Neural Network)

The CNN algorithm is a powerful deep learning method used for image classification and feature extraction from medical images such as CT scans. It works by processing the input image through a series of convolutional layers, pooling layers, and fully connected layers. This allows the network to learn complex features and patterns within the image data,improving accuracy and performance. In this analysis, we will train a CNN model with multiple convolutional layers and pooling layers.

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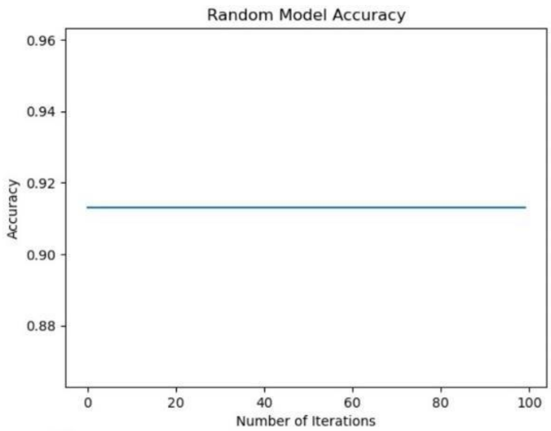
RESULTS

The Random Forest algorithm obtained an accuracy rate of 91.1% (see Figure 4), along with a sensitivity of 90%, precision of 94.7%, and specificity of 93.1%. Moreover, the Random Forest model generated Figure 5, which visualizes the prediction results of the tested images.



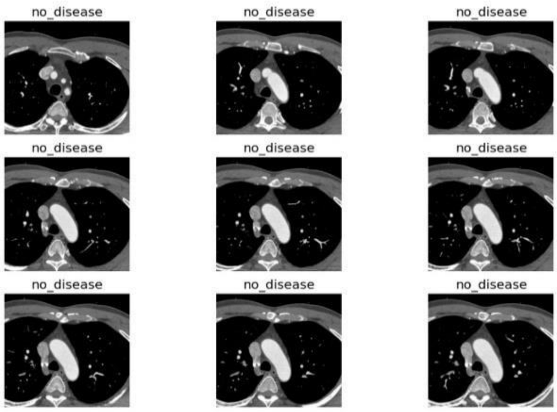
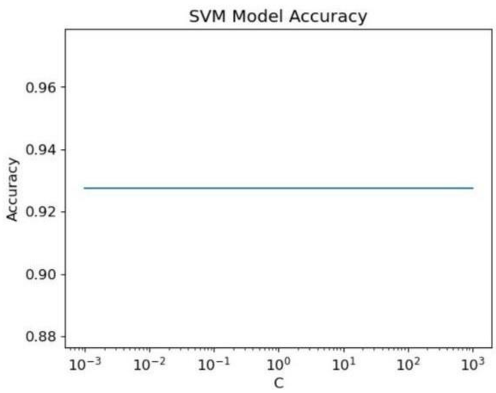


Fig 4: Random Forest model accuracy

Fig 5: Random Forest algorithm results

The accuracy achieved by the SVM model was 92.8% (as shown in Figure 6), with a sensitivity of 92.5%, a precision of 94.9%, and a specificity of 93.1%. The prediction results were also presented in the form of an image (Figure 7) generated by the SVM model.



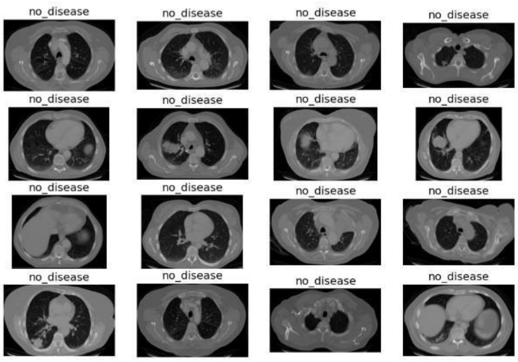


Fig 6: SVM model accuracy

Fig 7: SVM algorithm results

The CNN model yielded an accuracy of 98.6% (as shown in Figure 8), with a sensitivity of 95%, precision of 100%, and specificity of 100%. The model's prediction results are presented in Figure 9.

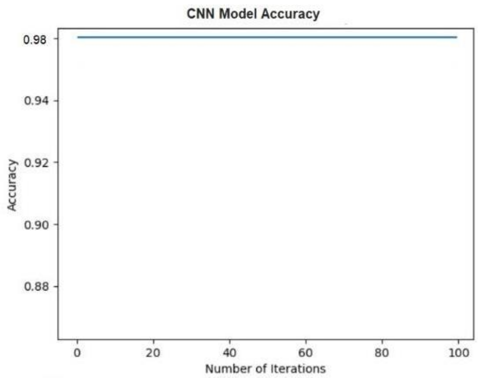


Fig 1: CNN model accuracy

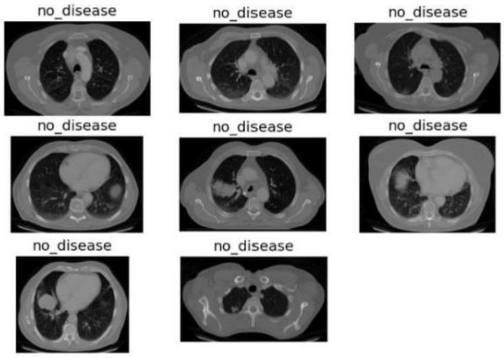


Fig 8: SVM algorithm results

Compared to the machine learning algorithms, the Convolutional Neural Network (CNN) achieved significantly higher accuracy in detecting and predicting heart disease, with an accuracy of 98.6% (refer to Figure 9). In contrast, the Random Forest model achieved an accuracy of 91.1% and the SVM achieved an accuracy of 92.8%.

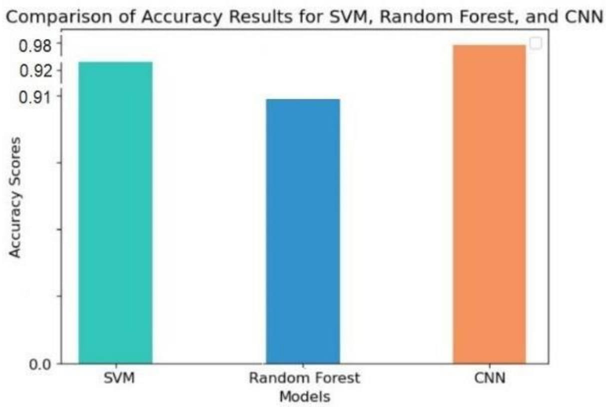


Fig 2: Accuracy Results

CONCLUSION

In conclusion, both Random Forest and SVM models were effective in detecting and predicting heart disease, but the CNN model achieved higher performance metrics. While the differences in accuracy are minor, the choice of algorithm may depend on the specific application. Therefore, a combination of all three algorithms could potentially increase accuracy in heart disease detection and prediction. The study also found that increasing the number of iterations improved the accuracy of all three models.

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