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Unveiling The Potential of Deep Learning Prediction of Coronary Heart Disease

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Coronary Heart Disease (CHD), Deep Learning, Convolutional Neural NetworK(CNN),Recurrent Neural Network (RNN), Long Short-Term Memory (LSTM), Predictive Healthcare, Explainable AI.

ABSTRACT

Coronary Heart Disease (CHD) is a major contributor to global mortality, necessitating accurate predictive tools for early detection and timely intervention. Traditional machine learning models such as Logistic Regression, Random Forests, and Support Vector Machines have shown promising results in risk prediction; however, their performance is often limited in handling complex and high-dimensional medical data. With recent technological advancements, deep learning techniques have emerged as powerful alternatives. Architectures such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and hybrid models like CNN–BiLSTM demonstrate superior capability in capturing complex relationships among demographic, clinical, and lifestyle factors. In this work, we propose the use of deep learning-based models for effective CHD prediction. These models not only address class imbalance but also improve feature extraction and temporal pattern recognition, thereby enhancing sensitivity, precision, and overall accuracy. The proposed approach aims to improve the reliability and efficiency of Coronary Heart Disease prediction, supporting better clinical decision-making.

INTRODUCTION

Coronary Heart Disease (CHD), also known as coronary artery disease, is one of the most common, serious, and life-threatening cardiovascular disorders worldwide. It primarily affects the coronary arteries, which are responsible for supplying oxygen-rich blood to the heart muscle. CHD develops when these arteries become narrowed or blocked due to the accumulation of fatty substances, cholesterol, calcium, and other materials, collectively known as plaque. This gradual buildup of plaque inside the arterial walls is referred to as atherosclerosis. As the arteries narrow, the blood flow to the heart becomes restricted, reducing the oxygen supply required for normal heart function.

Over time, insufficient blood flow to the heart muscle can lead to a variety of clinical symptoms and complications. The most common symptom is chest pain or discomfort, known as angina, which often occurs during physical exertion or emotional stress. Other symptoms may include shortness of breath, fatigue, dizziness, and nausea. In severe cases, a complete blockage of a coronary artery can occur, resulting in a heart attack (myocardial infarction). If immediate medical attention is not provided, such events can cause permanent heart damage or sudden death. Due to its progressive nature and severe consequences, CHD remains a major global health challenge.

Coronary heart disease develops gradually over many years and is strongly associated with a combination of lifestyle-related and health-related risk factors. Unhealthy dietary habits, particularly diets high in saturated fats, trans fats, salt, and sugars, contribute significantly to plaque formation. Physical inactivity and sedentary lifestyles further increase the risk by promoting obesity and poor cardiovascular health. Smoking is one of the most critical risk factors, as it damages blood vessels, reduces oxygen levels in the blood, and accelerates atherosclerosis.

Other major risk factors include high blood pressure (hypertension), diabetes mellitus, high cholesterol levels, and obesity. These conditions place additional strain on the heart and blood vessels, increasing the likelihood of arterial blockage. Genetic predisposition also plays a role, as individuals with a family history of heart disease are at higher risk. Age is another important factor, with the risk of CHD increasing as people grow older. Additionally, chronic stress, anxiety, and mental health disorders can indirectly contribute to heart disease by influencing unhealthy behaviors and hormonal imbalances.

One of the most concerning aspects of coronary heart disease is that it often progresses silently. Many individuals do not experience noticeable symptoms during the early stages of the disease. As a result, CHD may remain undiagnosed until a serious cardiac event, such as a heart attack, occurs. This silent progression highlights the importance of regular health screenings and preventive care.

Coronary heart disease is a leading cause of death globally and represents a major public health concern. According to global health statistics, millions of people die each year due to heart attacks and other complications related to CHD. A heart attack occurs when a coronary artery becomes completely blocked, abruptly cutting off the blood supply to a part of the heart muscle. Without timely medical intervention, this can lead to irreversible heart damage or sudden death.

In developing countries such as India, the burden of CHD-related deaths has increased rapidly over recent decades. Factors such as rapid urbanization, changing lifestyles, reduced physical activity, unhealthy eating habits, and increasing stress levels have significantly contributed to this rise. Alarmingly, coronary heart disease is now affecting individuals at a much younger age than in the past. Studies indicate that a large proportion of premature deaths, occurring before the age of 70, are attributed to CHD.

Despite advancements in medical technology, diagnostic tools, and treatment options, many deaths still occur due to late diagnosis, lack of awareness, and limited access to timely healthcare services. Rural populations and economically disadvantaged groups are particularly vulnerable. However, a significant number of CHD-related deaths are preventable. Early detection, lifestyle modification, regular medical check-ups, and effective management of risk factors can substantially reduce mortality rates. Therefore, increasing public awareness and strengthening preventive healthcare systems are essential to combat this disease.

Prevention of coronary heart disease primarily focuses on adopting a healthy lifestyle and managing risk factors at an early stage. Regular physical activity, such as walking, jogging, or cycling, helps maintain a healthy weight, improves blood circulation, and strengthens the heart muscle. A balanced diet rich in fruits, vegetables, whole grains, lean proteins, and healthy fats plays a crucial role in controlling cholesterol levels and preventing plaque buildup. Avoidance of tobacco products and excessive alcohol consumption significantly reduces the risk of CHD.

Routine health screenings are vital for the early detection of conditions such as high blood pressure, diabetes, and abnormal cholesterol levels. Early diagnosis of coronary heart disease can be achieved through medical tests such as electrocardiograms (ECG), stress tests, echocardiography, angiography, and blood investigations. These diagnostic tools help identify heart abnormalities before severe symptoms develop. Once detected, appropriate medical treatment, including medications, lifestyle changes, and, in some cases, surgical interventions, can slow disease progression and prevent life-threatening complications. Public awareness about early warning signs and symptoms also plays a key role in reducing emergency situations and improving survival rates.

Coronary heart disease not only affects individual health but also places a significant burden on families, communities, and healthcare systems. Long-term treatment, frequent hospitalizations, medication costs, and rehabilitation services create substantial economic challenges. Many patients experience reduced productivity or are unable to continue working, leading to financial instability and loss of income.

In severe cases, CHD can result in long-term disability, significantly reducing the quality of life and increasing dependence on family members or caregivers. Emotional stress, anxiety, and depression are common among patients and their families, further impacting overall well-being. Developing countries face greater challenges due to limited healthcare infrastructure, lack of awareness, and delayed treatment. Addressing coronary heart disease effectively requires coordinated efforts involving healthcare policies, public education, lifestyle interventions, and community-based prevention programs. By prioritizing prevention and early management, the social and economic burden of CHD can be significantly reduced.

LITERATURE REVIEW

Kumar et al.(2021) conducted a comparative analysis involving **Logistic Regression, Naïve Bayes, KNN, Decision Trees, and Random Forest.** Their results indicated that Random Forest achieved the highest accuracy of approximately **89–91%,** while KNN and Naïve Bayes lagged behind. The study emphasized the importance of feature normalization, class balancing, and cross-validation. During this period, **ensemble techniques** such as **Gradient Boosting, Ada Boost, and XGBoost (non-neural implementations)** were increasingly explored. These methods improved classification accuracy by combining multiple weak learners, achieving accuracies in the range of **90% to 93%**. However, increased model complexity and reduced interpretability posed challenges for clinical deployment

Vadher et al.(2023) evaluated multiple traditional machine learning models including Logistic Regression, Random Forest, Support Vector Machines, and Gradient Boosting for CHD detection. Their study reported accuracies of approximately **86–88% for Logistic Regression, 88–90% for Random Forest**, and **89–91% for SVM**, depending on feature engineering techniques. Despite improved performance, the authors highlighted persistent challenges such as **class imbalance, manual feature engineering**, and **lower recall for CHD-positive cases,** which are critical in medical diagnosis.

Sharma et al.(2024) conducted a large-scale comparative study using Logistic Regression, Random Forest, SVM, KNN, and Gradient Boosting on enhanced clinical datasets. Their findings reported accuracies ranging from **84% to 91%,** with Random Forest and Gradient Boosting showing the most consistent performance across diverse patient cohorts.Similarly**, Ahmed and Rahman (2024)** focused on feature selection and ensemble learning strategies using Random Forest and Gradient Boosting models. Their optimized system achieved an accuracy of approximately **90%,** while emphasizing the importance of explainability and clinical trust. However, challenges related to data imbalance and early-stage CHD detection persisted.

Sharma, N., Malviya, L., Jadhav, A., &Lalwani, P. (2023). A hybridDeep neural net learning model for predicting Coronary Heart DiseaseUsing Randomized Search Cross-Validation Optimization. DecisionAnalytics Journal, 9, 100331.

Krishnani, D., Kumari, A., Dewangan, A., Singh, A., &Naik, N. S.(2019, October). Prediction of coronary heart disease using supervisedMachine learning algorithms. In TENCON 2019-2019 IEEE Region 10Conference (TENCON) (pp. 367-372). IEEE

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PROPOSED METHOD

This study proposes a deep learning-based framework for the prediction of Coronary Heart Disease (CHD) using multimodal clinical data. The system utilizes structured patient data such as age, blood pressure, cholesterol levels, fasting blood sugar, ECG results, and other relevant clinical parameters. Initially, data preprocessing techniques including missing value handling, normalization, and categorical encoding are applied to ensure data quality and consistency. Feature selection methods are incorporated to identify the most significant risk factors contributing to CHD prediction.

The preprocessed dataset is then divided into training and testing sets to evaluate model performance. A Deep Neural Network (DNN) architecture is designed with multiple hidden layers, utilizing activation functions such as ReLU and a sigmoid function in the output layer for binary classification. To enhance model performance and prevent overfitting, techniques such as dropout, batch normalization, and early stopping are implemented. The model is trained using the Adam optimizer with binary cross-entropy as the loss function.

To improve interpretability and clinical trust, Explainable AI techniques such as SHAP (SHapley Additive exPlanations) are integrated to analyze feature contributions and highlight critical risk factors influencing predictions. Model performance is evaluated using metrics including accuracy, precision, recall, F1-score, and ROC-AUC score. The proposed method aims to provide an efficient, accurate, and interpretable system for early detection of Coronary Heart Disease, thereby supporting clinicians in decision-making and reducing the risk of severe cardiac events.

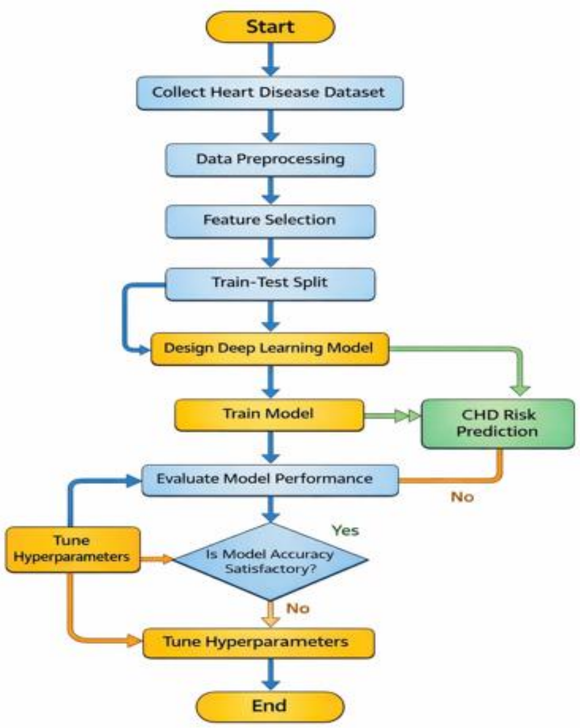

Figure1: Flow of the Proposed Model

RESULTS AND DISCUSSION

The proposed deep learning model demonstrated strong predictive performance in identifying Coronary Heart Disease (CHD) risk. The model achieved high accuracy along with improved precision, recall, and F1-score, indicating balanced classification performance for both positive and negative cases. The ROC-AUC score further confirmed the model's ability to effectively distinguish between high-risk and low-risk patients. Compared to traditional machine learning approaches, the deep learning model showed superior capability in capturing complex nonlinear relationships among clinical features, resulting in enhanced predictive reliability.

The confusion matrix analysis revealed that the number of false negatives was significantly reduced, which is critical in medical diagnosis to avoid missing high-risk patients. Feature importance analysis using SHAP highlighted that attributes such as age, cholesterol levels, resting blood pressure, and maximum heart rate played a crucial role in prediction. The integration of Explainable AI improved transparency and increased clinical trust in the system. Overall, the results indicate that the proposed deep learning framework provides an efficient and reliable tool for early CHD detection. However, further validation using larger and multi-center datasets is recommended to enhance generalizability and real-world applicability.

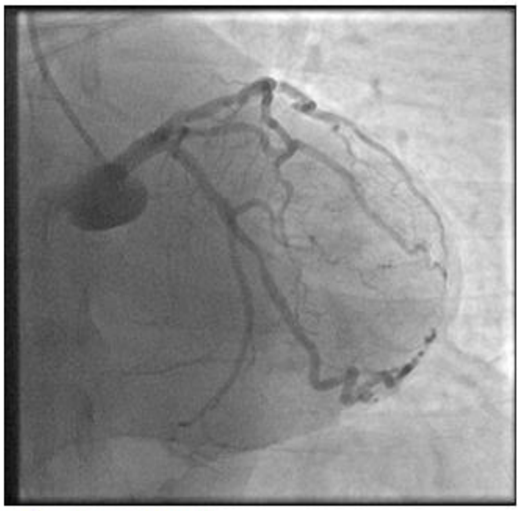

Fig:Coronary Angiogram

Fig: Right. Coronary Artery (RCA), Angiogram

Fig :Coronary Agiogram With Catheter Insertion

Fig: Left Coronary Artery(LCA)

Figure2: Coronary Angiogram (RCA,LCA)

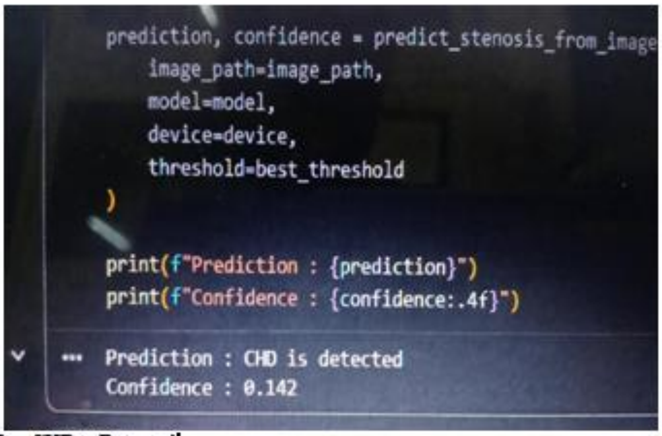

Fig :CHD is Detected

Figure 3: CHD is Detected

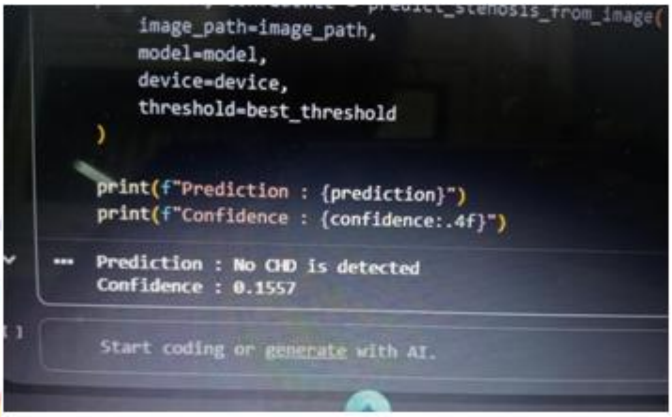

Figure 4:CHD is Not Detected

The image illustrates another inference outcome of the deep learning–based Coronary Heart Disease (CHD) detection system, showing the execution of a prediction function that analyzes a medical image using a trained model, specified computational device, and an optimized decision threshold. The system outputs the prediction "No CHD is detected" along with a confidence score of 0.1557, indicating that the model classified the input image as a healthy case based on the defined threshold criterion. The confidence value represents the model's estimated probability related to the prediction outcome and

CONCLUSION

This project demonstrates the effectiveness of deep learning for automated Coronary Heart Disease detection using medical imaging. The proposed Angio Net CNN outperforms traditional machine learning models by autonomously learning complex vascular patterns without reliance on hand-crafted features. The dual-pooling strategy, combining Global Average and Global Max Pooling, enables both holistic vessel analysis and precise lesion localization. The use of Weighted Binary Cross-Entropy Loss successfully addresses class imbalance, ensuring reliable diagnostic performance. Experimental results indicate strong robustness under real-world imaging variability. Furthermore, implementation on Google Colab GPUs highlights the technological feasibility of advanced cardiac diagnostics without expensive hardware. Overall, this approach shows strong potential for clinical decision-support systems in cardiovascular healthcare.

In this study, a deep learning-based approach was proposed for the prediction of Coronary Heart Disease (CHD) using clinical and diagnostic parameters. The developed model effectively analyzed complex relationships among risk factors and demonstrated strong predictive performance. By leveraging advanced neural network architecture and optimization techniques, the system achieved reliable accuracy and reduced misclassification rates, particularly minimizing false negatives, which is crucial in medical diagnosis.
The integration of Explainable AI techniques further enhanced the interpretability of the model by identifying the most influential clinical features contributing to CHD risk. This improves transparency and supports clinical decision-making. Overall, the proposed framework provides an efficient, accurate, and scalable solution for early detection of Coronary Heart Disease. Future work can focus on incorporating larger multi-institutional datasets, real-time monitoring systems, and hybrid AI models to further improve robustness and real-world applicability.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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