International Journal of Electrical, Electronics and Computer Engineering **14**(1&2): 55-57(2025)

ISSN No. (Online): 2277-2626

A Comprehensive Literature Review on Detection of Heart Disease Approaches Using Deep Learning

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(Received: 03 March 2025, Accepted: 06 April 2025)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Heart disease is one of the reasons to the human death. Detection of heart diseases at early stages is essential for timely intervention and treatment. Deep learning plays an important role in the field of medical science. Recently, there has been great interest into the use of deep learning algorithms, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and their hybrids, for the purpose of heart disease detection due to the ability of deep learning to process medical data including ECGs, medical imaging, and health records. The ability of CNNs to process images of echocardiograms, CT scans, and MRI scans into real life application comes from its incredible ability to extract features from images. This literature review seeks to evaluate the available literature from the development of deep learning models, specifically with regards to CNNs, to detect heart disease, their architecture, dataset used, barriers in the field, and identified gaps. Lastly, this literature review provides suggestions for further work on improving the scope and efficiency of deep learning algorithms in the cardiovascular sector to upgrade functionality and usability.

Keywords: CNN, RNN, Hybrid CNN, AlexNet, ResNet-50, Inception-V3, Deep Learning, AI.

INTRODUCTION

One of the leading causes of death in the world is heart disease, which, if caught early, has the chance of being treated effectively. Traditional techniques for detecting heart problems usually consist of manual reviews of medical images of ECGs, echocardiograms, and CT scans. Because of their manual nature, they are also very prone to human error, particularly with large datasets. CNNs, which stands for convolutional neural networks, are a subtype of deep learning technology, which is increasingly changing how heart diseases are diagnosed. Unlike conventional automated systems, CNNs can independently learn and identify features in medical images of different heart disease types. Because of this, they are instrumental in greatly increasing the speed and accuracy of diagnosing heart disease. Because CNNs learn images without the need for features to be defined, they are especially efficient in the analysis of medical images. They are capable of recognizing sophisticated patterns and anomalies that qualified doctors might miss. For instance, in learning to detect heart diseases, a CNN can be trained using vast amounts of data consisting of ECG signals, videos of echocardiograms, or even CT scans to detect indicators of heart failure, arrhythmias, or blockages of the coronary arteries. The trained CNN will then be able to promptly and accurately assess new medical images of a patient to assist physicians to provide prompt and precise diagnoses. The power of CNNs lie in their capacity to learn from data, which enables a new level of automated image understanding. They are automatically more effective with experience based on more examples, making it extraordinarily generalizable to various heart disease detection tasks. CNNs can also identify subtle patterns in images, such as abnormalities in the heart's structure or function, that may not be easy for humans to recognize. CNNs automate the detection process, saving time and reducing the risk of error, which in turn improves patient outcomes. This paper explores how CNNs are used to detect various heart conditions, and focus on their application to medical images such as ECGs and echocardiograms. This paper will also focus at the challenges faced such as the need for large and diverse datasets, improving model accuracy, and making CNNs more understandable for healthcare professionals.

RELATED WORK

In the last few years, many research papers have aimed to apply Convolutional Neural Networks (CNNs) to identify heart diseases from medical images. These studies have demonstrated the effectiveness of CNNs in enhancing diagnostic accuracy, streamlining the detection process, and accelerating the speed of heart disease diagnosis. Below are some of the most recent and notable studies that explore the application of CNNs in heart disease detection.

Rajpurkar *et al*. (2018) Cardiologist-Level Arrhythmia Detection with CNNs In this study, Rajpurkar and colleagues proposed a CNN model called ArrhythmiaNet for detecting arrhythmias from ECG signals. The authors trained the CNN model on a large dataset of over 15,000 ECG recordings, achieving accuracy levels comparable to expert cardiologists. The model achieved an accuracy of 94.6% across a range of arrhythmia types, including atrial fibrillation, premature

ventricular contractions, and others. This study demonstrated the potential of deep learning models to assist cardiologists in detecting arrhythmias, thus improving the overall diagnosis process and enabling faster clinical decisions.

Zhang *et al.* (2020), ECG Classification Using Convolutional Neural Networks, In this study, researchers Zhang *et al*. (2020) proposed a CNN based model to detect different types of arrhythmias obtained from ECG signals. The researchers processed a dataset with more than 20,000 normal and abnormal labeled ECG recordings. Important features were extracted from the ECG using wavelet transform and trained a CNN model with these features. The model achieved 97.2% accuracy in classifying arrhythmias and performed better than older methods based on set of rules and other machine learning algorithms. This shows the ability of CNN's to automate abnormal heart rhythm detection, which can help reduce time needed to take action

Ismail *et al.* (2021) Using CNN from CT Angiography detection of Coronery Artery Disease, Ismail *et al.* (2021) used CNNs for the detection of coronary artery disease (CAD) from CT angiography images. In their work, they trained a model to determine, from 3D computed tomography (CT) images, if a patient had significant blockages in the coronary arteries. The model applied 3D convolutional neural networks (CNNs) to capture the intricate spatial relationships in the CT scans and effectively segment the coronary arteries with blockages. The model was able to achieve a 92.5% accuracy score in CAD detection with a sensitivity of 93.3% and specificity of 91.2%. That proved that CNNs could aid in the workload of radiologists while improving the accuracy of CAD assessment.

Liu *et al.* (2022) Deep Learning for Detection of Cardiovascular Diseases Using Fundus Images In recent study, Liu and colleagues leveraged deep learning algorithms, particularly CNN, to identify cardiovascular diseases via retinal fundus photographs. The purpose of the study was to evaluate the fact that retinal tissue changes can frequently be signs of cardiovascular diseases. The CNN model was trained on a large fundus image dataset to look for signs of hypertensive retinopathy, an eye disease related to heart failure, and assess the cardiovascular risk. The model reached an accuracy of 93.5% in identifying cardiovascular malfunctions and evaluating the cardiovascular risk, thus highlighting the possibility for employing basic eye examinations as a diagnostic tool for early heart disease discovery.

Wang *et al.* (2023) Deep Learning for Early Detection of Cardiovascular Diseases Using ECG, Wang and colleagues suggested a hybrid deep learning model combining a convolutional neural network with a recurrent neural network for detecting cardiovascular diseases at an early stage using ECG data. This architecture was created in order to capture spatial features (using CNNs) and temporal dependencies (using RNNs). The hybrid CNN-RNN model was tested on the PTB-XL dataset filled with diverse ECG signals from patients suffering different heart diseases and was able to reach an accuracy of 97%.

Table 1: Comparative study of existing techniques.

Authors	Technique Used	Objective	Performance Metrics	Dataset	Simulator Outcomes
Wang *et al.* (2023)	Hybrid CNN-RNN model	Early detection of cardiovascular diseases using ECG signals	Accuracy, Precision	PTB-XL dataset	97% accuracy
Liu *et al.* (2022)	Deep Learning for Detection of Cardiovascular Diseases Using Fundus Images	Detect cardiovascular diseases from retinal fundus images using deep learning	Accuracy	**EyePACS dataset** (retinal fundus images)	93.5% accuracy
Ismail *et al.* (2021)	CNN-based approach for coronary artery disease detection	Detection of coronary artery disease from CT angiography images	Accuracy, Precision, Specificity	CT Angiography dataset	92.5% Accuracy in detecting CAD, with 93.3% sensitivity and 91.2% specificity.
Zhang *et al.* (2020)	Convolutional Neural Networks (CNN)	ECG classification for detecting arrhythmias using deep learning	Accuracy	MIT-BIH Arrhythmia dataset	97.2% accuracy
Rajpurkar *et al.* (2018)	Convolutional Neural Networks (CNN)	Cardiologist-level arrhythmia detection from 12-lead ECG	Accuracy, Specificity	Physionet's 12-lead ECG dataset	94.6% accuracy

REREARCH GAP

This literature review presents comprehensive studies in the field of heart disease recognition and detection systems. This broad literature review serves as a roadmap to uncover the limitations of current approaches and leads to the improvement of well-defined research problems. After such a broad review, it was found that in the past decades, deep learning based

CNN algorithms have been highlighted as one of the significant methods being researched in medical domains. Despite the fact that various deep learning algorithms have been applied and developed for heart disease diagnosis and detection, this is still an area of research and should result in improvements for better diagnosis of heart diseases. From this literature review, we found that there is a lack of reliable publicly available heart diseases datasets. Therefore, it is necessary to improve and construct a new dataset that includes various heart diseases.

FINDING SUGGESTIONS

This review discusses the problems and challenges associated with using Convolutional Neural Network (CNN) algorithms to identify heart diseases. The main challenges include setting model parameters correctly and avoiding overfitting. Previous models have limitations in properly utilizing the advantages of Image Augmentation techniques. Our proposed model uses various Image Augmentation techniques, such as Canny Edge Detection, Flipping, Blurring, to enhance our dataset. These techniques can help build a robust model. The performance of many of the previously proposed models was inadequate, especially in challenging cases. It also indicates that many current systems have not used pre trained models such as AlexNet, ResNet-50, and Inception-V3 for detecting heart diseases. Additionally, no attempts have been made to combine two CNN models running side-by-side. There is a need for a better CNN approach to balance the accuracy and efficiency in identifying heart diseases. Developing a new approach is essential to help doctors quickly detect and classify diseases. This new approach focuses on fine tuning the model parameters and using data augmentation to address the existing challenges. This review highlights that current algorithms often show low accuracy, emphasizing the importance of continuous improvement. By solving these issues, a new CNN model can greatly enhance the early detection of heart diseases and assist doctors in managing their patients more effectively. This research gap motivated us to create a deep learning model for detecting heart diseases.

CONCLUSIONS

In conclusion, advancements in AI, CNNs, and DL models have significantly improved the heart disease detection and classification accuracy. Techniques such as hybrid model feature selection, and domain-specific optimization have played key roles in achieving high accuracy across diverse datasets. There is a need for a better CNN approach balances accuracy and efficiency in identifying heart diseases. Developing a new approach is essential to help doctors quickly detect and classify diseases in heart. This new approach will focus on fine-tuning model parameters and using data augmentation to address existing challenges. The review highlights that current algorithms often show low accuracy, emphasizing the importance of continuous improvement. By solving these issues, a new CNN model could greatly enhance the early detection of heart diseases. This gap in research motivates us to create a deep learning model for detecting heart diseases.

Acknowledgement. The author would like to express her sincere gratitude to all the faculty members of department for their invaluable guidance, unwavering support, and continuous encouragement throughout the course of this research endeavor.

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