

Detection of Cardiovascular Diseases in ECG Images Using Deep Learning Methods

Swathi ¹, Dr. Swaroopa Shastri²

¹Student, Dept. Of MCA, VTU CPGS Kalaburagi, India.

²Assistant Professor, Dept. Of VTU CPGS Kalaburagi, India.

ABSTRACT

Cardiovascular diseases constitute the primary killers worldwide. The earlier they can be predicted and classified the more lives can be saved. According to the (WHO), in 2022, C-V-D claimed the lives of approximately 19.1 million people, accounting for 33% of global fatalities. (ECG) is popular for use in automated recognition of C-V-D using traditional machine learning. However, it is usually difficult to select optimal features. The Electrocardiogram ((ECG)) Signals are mainly used as diagnostic tools that routinely assess the electrical and muscular function of the heart. The proposed work comprising data collection, storage, and processing components, the system employs a convolutional neural network (CNN) model for cardiac abnormality prediction. Different image pre-processing method used to improve quality individual (ECG) images the performance indicators of the proposed C-N-N model achieves 94.87% accuracy, 68.08% recall, 84.16% precision.

Key Words: Cardiovascular, deep learning, electro cardiogram (ECG) images, feature extraction, machine learning, transfer learning.

1. INTRODUCTION

Detection of cardiovascular diseases through the analysis of Electrocardiogram ((ECG)) images represents a critical endeavor in modern healthcare, driven by advancements in M-L and D-L techniques. Cardiovascular diseases, including conditions like arrhythmias and myocardial infarctions, continue to pose significant health risks globally, underscoring the urgent need for accurate and timely diagnosis. The Electrocardiogram, a fundamental tool in cardiology, records the electrical activity of the heart and provides essential diagnostic information. Its non-invasive nature and widespread availability make it an ideal candidate for automated analysis using computational methods. In M-L and D-L architectures have shown promise in deciphering complex patterns within (ECG) signals, enabling the detection of subtle abnormalities that might escape traditional analysis. The point of this revise is to improve the identification and categorization of cardiovascular disorders from (ECG) pictures by utilizing artificial intelligence. By leveraging large-scale datasets of (ECG) recordings from diverse patient populations, the study seeks to develop robust predictive models capable of distinguishing between various cardiac conditions with elevated accuracy and reliability. Key objectives include investigating state-of-the-art deep extracting features using learning models and classification tasks, exploring novel architectures tailored to the complexities of (ECG) data, and integrating these advancements into clinical workflows. The final goal is for cardiovascular diseases, thereby improving patient outcomes and reducing healthcare costs. This

initiative aims to advance cardiovascular diagnoses through interdisciplinary collaboration between cardiologists, medical researchers, and machine learning specialists, opening the door to more individualized

and efficient healthcare solutions. By combining cutting-edge technology with clinical expertise, it aspires to set new benchmarks in the field of cardiovascular disease detection and inspire future innovations in medical imaging and diagnostics. If cardiovascular disease is effectively diagnosed and treated at an earlier stage, many lives can be spared. Artificial intelligence advancements in healthcare have the potential to significantly lower medical errors. Specifically, the automated detection of cardiac diseases by using deep learning techniques. Cardiovascular illnesses have made extensive use approaches. It also proposes a novel model for cardiac illness forecasting with C-N-N's. (ECG) images and used for feature extraction of the (ECG) images after training the new proposed ((CNN)) model [1]. Improved lifestyle choices have a direct impact on reducing the frequency of persistent diseases. Among nations, (US) bears the greatest burden of chronic diseases. The US allocates approximately \$2.70 trillion each year for the treatment of these diseases, which constitutes 18.0% of the nation's gross domestic product. In particular, cardiovascular disease (CVD) stands out as the primary the reason behind the death in the Americas. In a comparable way, other nations around the world are dealing with the issues associated with CVD. According to studies public, Chronic illnesses are to blame for 86.5% of deaths in China [2]. With the continuous progress of science and technology, the computing power of computers has been enhanced, and artificial intelligence applied and popularized. Therefore, if AI technology can be effectively used to predict whether a person has cardiovascular disease and intervene in advance, it will save people's lives and reduce the workload of doctors. AFM is a supervised learning model. It adds second-order feature interaction on the basis of linear regression. It uses hidden variables for inner product to achieve interaction, which alleviates the problem of parameter training difficulties caused by sparse data [3]. All most (CVD) may be eliminated by addressing observable risk factors, such as tobacco use, unhealthy eating habits and obesity, physical inactivity, and harmful alcohol use in population-wide settings. Early introduction and management using brief prescriptions is important for them who suffer with cardiovascular disease (CVD) or who are at high cardiovascular hazards since at least one risk factor is present, such as hypertension, diabetes, hyperlipidaemia, or effectively settled illness [4]. The authors of suggested two deep neural networks to establish accurate estimation of the risk of coronary heart disease using well-organized training datasets. Most real-world datasets include erratic data that prediction methods can't learn to deal with. They proposed building training datasets by separating regular from a very biased subset, instead than depending on whole or randomly selected datasets. The production of training data entails two steps: By dividing the initial training datasets into two groups—one with a large geographical distribution and another with a large skew—variable autoencoders are able to enhance the biased set. Training two independent deep neural network classifiers is the last phase. [5].

2. LITERATURE REVIEW

Many research works have been conducted for automatically predicting cardiovascular diseases using machine learning and deep learning methods by utilizing ECG as digital or images data representation. Mohammed B. Abubaker et al. [1] compared machine learning and deep learning methods on the basis of ECG Images Dataset of Cardiac Patients dataset contains 928 different patient records with 4 different classes These four classes are NP, AH, MI, and H. MI. Gamma correction, image resizing, and z-score normalization were used as pre-processing steps for the ECG images. The machine learning algorithms namely support vector machine, K-nearest neighbors, decision tree, random forest, and Naïve Bayes. According to the experimental results, the performance metrics of the proposed CNN model outperform the exiting works; it achieves 98.23% accuracy, 98.22% recall, 98.31% precision, and 98.21% F1 score. T.Ullah

et al. [2] compared accurate prediction of cardiac issues is crucial for providing optimal care to patients. The first dataset used for CVD is Hungarian Heart Disease Dataset (HHDD). The 2nd dataset used in this study is the Kaggle. The classifiers (KNN, Naive Bayes, and Decision Tree) are tested for detecting normal and abnormal heart rhythms, with the Decision Tree performing best. Extra Tree and Random Forest classifiers trained on the selected features have achieved no table performance rates with accuracy of 100% respectively. Lei Miao et al. [3] proposed a Cardiovascular Disease Prediction Based on Soft Voting Ensemble Model. The dataset is downloaded from Kaggle; this dataset contains a total of 70,000 samples. The soft voting ensemble of LR and KNN based classification method for early monitoring of cardiovascular diseases. This Experiments show that the ALD-SVE model has excellent performance in cardiovascular disease datasets, and its AUC value reached 0.80306, better than the listed comparison Model. N. Komal Kumar et al. [4] proposed an Analysis and Prediction of Cardio Vascular Disease using Machine Learning Classifiers. They worked on heart disease dataset obtained from UCI repository; the dataset contained 10 attributes and target with 304 instances. The preprocessing techniques are Data Integration, Data transformation, Data reduction, and Data Cleaning using panda's tool. Machine learning tree classifiers, for example, Random Forest, Decision Tree, Logistic Regression, Support vector machine (SVM), K-nearest neighbor's (KNN) were breaking down dependent on their precision and AUC ROC scores. The Random woodland Machine learning classifier accomplished a higher precision of 85%, ROC AUC score of 0.8675 and execution time of 1.09 sec. Surjeet Dalal et al. [5] proposed as a new way to predict obesity risk. Obesity and its underlying causes are the focus of this research. It is estimated that more than 1100 people of all ages and socioeconomic backgrounds participated in the survey. The proposed study covered nine machine- learning techniques. K-NN, multilayer perceptron's (MLP), random forest, Naïve Bayes, support vector machines (SVM), adaptive boosting (ADA), logistic regression, decision trees, and gradient boost classifiers were all evaluated for their eNcacy. High-, medium-, and low-obesity individuals were categorized into three groups. Classifiers using the logistic regression algorithm achieve a correctness rate of 97 percent, which is higher than any other approach. Accuracy was 64.08 percent, and metrics were the lowest. Mehdi Fasihi et al. [6] introduced novel method for ECG Arrhythmia. The Arrhythmia dataset contains 452 ECG samples and 279 attributes with a 33% missing value that was formulated by the use of a 12 ECG lead. The proposed architecture consists of four convolution layers, three pooling layers, and three fully connected layers evaluated on the arrhythmia dataset. The proposed architecture outperforms other existing classifiers such as conventional 1-D CNN, neural network, SVM, k-nearest Neighbour, decision tree, logistic regression, naive Bayesian and deep belief network in terms of accuracy, sensitivity, and specificity, and also competitive with state-of-the-art works in terms of accuracy. Md. Nahid Hasan et al. [7] conducted a Detection of Cardiovascular Disease from ECG Image Using Optimized Weighted Average Ensemble Machine Learning Technique. The dataset contains 1687 images of 12- lead in version 1 and 928leadimagesinversion 2. The preprocessing techniques are canny edge detection, morphological operation, Otsu thresholding, and inverse contour in each image. The proposed model shows state-of-the- art results in accuracy, precision, recall, and f1-score of 99.29%, outperforming the existing work. The model has attained an Area under Curve (AUC) score of 99.96%. Elias Dritsas et al. [8] Proposed a Cardiovascular Disease Risk prediction with supervised Machine learning techniques. An open- source dataset derived from Kaggle, which consists of 70000 participants. The data pre-processing was evaluated using Stata V.14 tool kit. Stata is a

general- purpose statistical software package developed by Stata Corp for data manipulation, visualization, statistics, and automated reporting the experimental analysis demonstrated that the Logistic Regression classifier is the most appropriate against Naive Bayes, Support Vector Machine (SVM) and Random Forest with 72.1% accuracy, recall and 78.4% AUC. Ambrish G et al. [9] Logistic regression technique for prediction of cardiovascular disease. The cardiac disease dataset obtained from the UCI ML repository. The first process is Data Retrieval. In this process, Heart Disease UCI Dataset-published by Ronit in Kaggle website (<https://www.kaggle.com/ronitf/heart-disease-uci>)-will be used. The data in this study contain 14 variables with 76 attributes and 304 responses as the basis for analysis. The pre-processing methods are used as Data Loading, Error Handling, Handling Missing Data, Feature Selection. The LR (Logistic Regression) is the supervised ML binary classification algorithm widely used in most application with the accuracy of the prediction results with the algorithm reaches 85% with an error rate that tends to be small at 0.1406565. Anitha K et al. [10] Cardiovascular Disease Prediction based on ANN Algorithm. The data is We have collected Data such as age, gender, height, weight, BP readings (both systolic and diastolic), cholesterol, glucose, cigarette and alcohol consumption, exercise habits, and cardiac risk classification are kept in these databases. A specific value within the data set is called a "datum". When it comes to data mining and machine learning projects, the old adage "Garbage in, trash out" rings especially true. The heart attack prediction system proposed in this research uses deep learning techniques, more especially Multi-Layer Perceptron (MLP), to forecast the patient's likelihood of developing heart-related disorders. The Deep Learning technique in Artificial Neural Networks is used by MLP, a particularly potent classification system. Dheeraj Alamu et al. [11] Proposed a Cardiovascular Health Prognosis: Machine Learning Approaches for Precise Heart Disease Prediction. The Heart Disease Data Set sourced from the UCI ML Repository. This experiment selectively focuses on 14 pertinent attributes. The dataset comprises a total of

303 instances. The implementation of the PCA algorithm was carried out using the WEKA software. Three distinct Classification Algorithms, as enumerated in references, were applied to the dataset. These algorithms were chosen for their relevance and efficacy in the context of the study. 1. Random Forest (RF) 2. Decision Tree (DT) 3. Logistic Regression (LR). Nadiah A. Baghdadi et al. [12] conducted an advanced machine learning techniques for cardiovascular disease early detection. The Heart Condition data utilized in this study is a synthesis of data sets from the UCI Machine Learning Repository. The pre-processing method is SHAP (Shapley Additive ex Planations). The proposed Catboost model yields an F1-score of about 92.3% and an average accuracy of 90.94%. Therefore, compared to many other existing state-of-art approaches, it successfully achieved and maximized classification performance with higher percentages of accuracy and precision. Muhammad Waseem Anwar et al. [13] Developed an Integrated Machine Learning Framework for Effective Prediction of Cardiovascular Diseases. The primary dataset which we have used to demonstrate the applicability of our framework is Framingham data set. A MaLCaDD (Machine Learning based Cardiovascular Disease Diagnosis) framework is proposed for the effective prediction of cardiovascular diseases. An ensemble of Logistic Regression and K- Nearest Neighbour (KNN) classifiers is proposed for prediction with higher accuracy. The validation of framework is performed through three benchmark datasets (i.e. Framingham, Heart Disease and Cleveland) and the accuracies of 99.1%, 98.0% and 95.5 % are achieved respectively. A. Kapoor et al. [14] Proposed a Cardiovascular Disease Prognosis and

Analysis Using Machine Learning Techniques. The training and testing data sets are used. The algorithms such as Support Vector Machine (SVM), Naïve Bayes (NB), K-Nearest Neighbour (KNN), Genetic Algorithm (GA), Random Forest (RF), Artificial Neural Networks (ANN) or Gradient Boosting (GB). In order to help healthcare professionals forecast heart illness, researchers analyse enormous volumes of complex health records utilizing various statistical and machine learning (ML) techniques. The SVM algorithm has 99.13% accuracy, 98.22% sensitivity, specificity: 100% and 100% precision. B'arbara Martin et al. [15] compared a data mining for Cardiovascular Disease Prediction. The dataset used in this study was retrieved from the Kaggle data repository and is related with the detection of CVD cases, including 70000 registers of patients and 12 attributes considered relevant for identifying the disease. The Split Validations adequate for very large data and very complex preprocessing processes. The CRossIndustry Standard Process for Data Mining (CRISP-DM) methodology was followed, in which five classifiers were applied, namely DT, Optimized DT, RI, RF, and DL, with the best model being Optimized DT, which achieved the highest values for all the evaluation metrics, 73.54%, 75.82%, 68.89%, 78.16% and 0.788 for accuracy, precision, sensitivity, specificity, and AUC, respectively. Najmu Nisset al. [16] prepared an Early Detection of Cardiovascular Disease using Machine learning Techniques an Experimental Study. Two datasets have been obtained one containing 1026 instances and 14 attributes and the second one containing 303 instances and 14 attributes. The pre-processing has Handling Missing Data, Removing Noise, Standardization, Encoding Categorical Variables, Feature Selection/Extraction, Addressing Imbalanced Data. The six machine learning algorithms are used and then compared accordingly based on the evaluation of performance. Among all classifiers, decision tree outperforms over the other algorithms with a testing accuracy of 97.29%. Arsalan Khan et al. [17] Developed A Novel Study on Machine Learning Algorithm-Based Cardiovascular Disease Prediction. Data were collected from the two largest teaching hospitals, the Lady Reading Hospital (LRM) and the Khyber Teaching Hospital (KTH), in Khyber Pakhtunkhwa (KPK), one of the four provinces of Pakistan. The RF algorithm had the highest accuracy of prediction, sensitivity, and recursive operative characteristic curve of 85.01%, 92.11%, and 87.73%, respectively, for CVD. Rajkumar Gangappa Nadakinamani et al.

[18] Clinical Data Analysis for Prediction of Cardiovascular Disease Using Machine Learning Techniques. A total of 303 samples from the Kaggle dataset were considered. The first stage of data mining: the real-world data contains a large number of missing and noisy values. The modern machine learning algorithms such as REP Tree, M5P Tree, Random Tree, Linear Regression, Naive Bayes, J48, and JRIP are used to classify popular cardiovascular datasets. The Random Tree model performed admirably, with the highest accuracy of 100%, the lowest MAE of 0.0011, the lowest RMSE of 0.0231, and the fastest prediction time of 0.01 seconds. Luis Rolando Guarneros-Nolasco et al. [19] Identifying the Main Risk Factors for Cardiovascular Diseases Prediction Using Machine Learning Algorithms. They identified four main clinical datasets: the Cleveland dataset, the Framingham Heart study dataset, the Faisalabad Institute dataset, and the South African Hearth dataset. The classifiers comprise a linear statistical approach (linear Regression), three tree-based methods (Random Forest, XGBRF, and decision tree), one SVM, one instance-based learning model, and four ensemble boosting methods (Gradient Boosting, LightGBM, CatBoost, and AdaBoost). Wada Mohammed Jinjri et al. [20] Machine Learning Algorithms for The Classification of Cardiovascular Disease- A Comparative Study. The dataset used is obtained from the Kaggle repository. This dataset consists of 77,000 clinical trial records. The proposed five different classifiers are support vector machine (SVM), K-nearest neighbor (K-NN), Logisticregression (LR),

Decision tree (DT), and Naive Bayes (NB) for the classification of cardiovascular disease (CVD).

3. SYSTEM ANALYSIS

- **Existing System:**

Cardiovascular diseases are a leading cause of death worldwide, making early prediction and classification crucial for saving lives. The Electrocardiogram (ECG) is a common, inexpensive, and noninvasive tool used to detect cardiovascular disease by measuring the heart's electrical activity. Traditional methods of ECG analysis rely on highly skilled clinicians, but this manual process can be time-consuming and prone to errors. To address these limitations, machine learning and deep learning techniques have been employed for automatic prediction of heart diseases.

Deep learning, a subfield of machine learning, offers a more automated approach by creating models with multiple hidden layers that can automatically extract important features and patterns from training datasets. Convolutional Neural Networks (CNNs), a popular deep learning method, have shown promising results in image classification tasks, including ECG image analysis. Additionally, a new CNN architecture specifically designed for cardiac abnormality prediction has been proposed. Experimental results demonstrate that the proposed CNN model outperforms existing models, achieving high accuracy, recall, precision, and F1 score. When used for feature extraction, the proposed CNN model, combined with the NB algorithm, achieves the best classification accuracy.

- **Proposed System:**

The proposed system for detecting cardiovascular diseases from (ECG) images using Deep learning and machine learning methods aims to overcome existing limitations by leveraging advanced computational techniques. By integrating state-of-the-art deep learning architectures such as convolutional neural networks ((CNN) s) and recurrent neural networks (RNNs), the system seeks to automate and enhance the accuracy of disease detection. These models will be trained on diverse and large-scale datasets of (ECG) recordings to learn complex patterns indicative Many different heart ailments, such as myocardial infarctions, arrhythmias, and conduction disorders. The system will prioritize robustness and scalability, aiming to deliver reliable diagnostic in making timely and informed decisions. Through rigorous validation and optimization, the proposed system intends to achieve superior performance metrics compared to traditional methods, thereby perhaps enhancing medical care for patients and outcomes in clinical practice.

4. ARCHITECTURE:

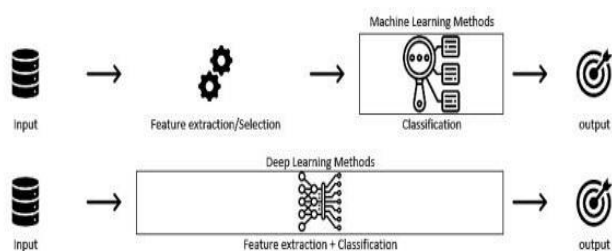


Fig. 1. Abstract concept of machine learning and deep learning.

5. METHODS

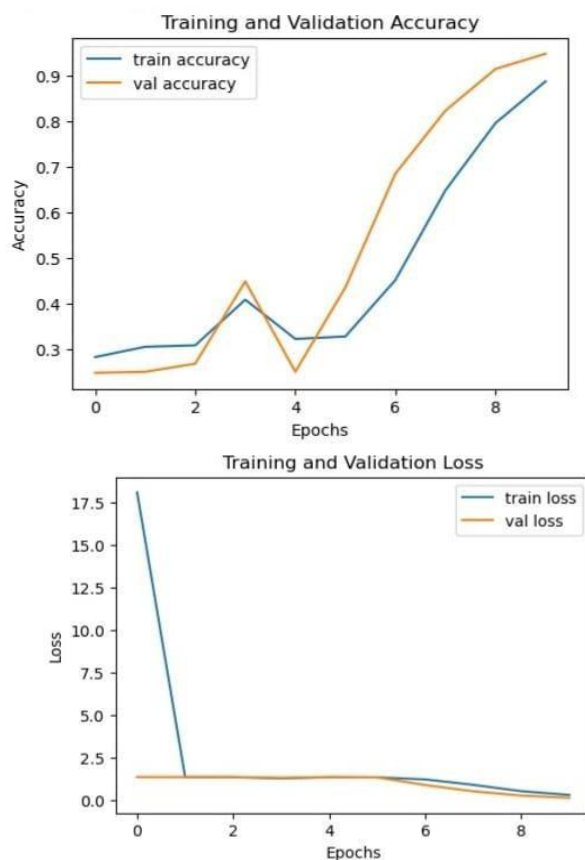
Convolutional Neural Networks (CNN)

A Convolutional Neural Network (CNN) is a deep learning model designed for image classification and processing. CNNs consist of neurons organized in three dimensions: height, width, and depth (channel). They utilize convolutional layers to extract features from input images and pooling layers to reduce computational cost by down sampling the feature maps. Activation functions like ReLU add nonlinearity to the model. The final layers are usually fully connected layers followed by a softmax or sigmoid activation function to produce the output.

Proposed CNN Architecture

The proposed CNN model consists of 38 layers, including six 2-D convolutional layers, three fully connected layers, three max-pooling layers, eight leaky ReLU layers, eight batch normalization layers, five dropout layers, two depth concatenation layers, and one softmax layer. The model features two branches: the stack branch and the full branch, both accepting input images of size $227 \times 227 \times 3$. The stack branch includes three stacked 2-D 3×3 convolutional layers, each followed by leaky ReLU, batch normalization, and max-pooling layers. The leaky ReLU activation helps prevent the dying neuron problem, while batch normalization speeds up training and improves accuracy. Max-pooling reduces the spatial size of the feature maps, lowering the number of parameters and computational cost.

6. RESULTS AND ANALYSIS:



7. CONCLUSION

In this proposed work, we provide a portable (CNN) - based model that uses a publically accessible dataset of (ECG) images of cardiac patients to categorized the four main cardiac abnormalities: atrial hypertrophy (AH), myocardial infarction (MI), heart block (H. MI), and normal sinus rhythm (NP). The untried findings prove to the (CNN) model performs notably better than previous machine learning classifiers into conditions of classification accuracy for cardiovascular illness. It also functions well as an efficient implement for extract type for these classifiers. The performance metrics of the future (CNN) model achieves 94.87% accuracy, 68.08% recall, 84.16% precision.

8. FUTURE WORK

The improvement of the (CNN) model's effectiveness in classifying cardiovascular diseases, optimize hyperparameters, and develop a multi-class classification method. To ensure reliable training and validation, more (ECG) images are needed. Utilizing CNN to diagnose cardiovascular illness based on electrocardiograms is a major advancement in the application of machine learning to medical diagnosis. Furthermore, investigating interpretability strategies like saliency maps and attention mechanisms may shed light on the CNN's decision-making process, boosting its usability and credibility in clinical contexts. Investigating the integration of multimodal data, like merging ECG with additional medical imaging, may improve diagnostic accuracy even more.

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