

ECG IMAGE-BASED CARDIOVASCULAR DISEASE IDENTIFICATION USING DEEP LEARNING

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Abstract

Cardiovascular diseases (CVDs) are one of the primary reasons for death across the globe which must require the early diagnosis system. Therefore, we propose a deep learning system for detection of cardiovascular diseases based on the ECG image. The system utilizes Convolutional Neural Network (CNN) as a framework of VGG16 model to automatically discover effective patterns and features of ECG signals from the image. First, ECG images are preprocessed including removing noise, normalization, and segmentation to enhance data quality. Then, the features of ECG signals which are related to the abnormalities of heart are extracted. Finally, a deep learning model is trained to classify the ECG image to classify cardiovascular diseases such as arrhythmia, myocardial infarction, and irregular heart beat pattern. Our system result shows that has increased the accuracy and speed up the process of diagnosing the heart disease to assist the doctor's decision.

Keywords: Cardiovascular Disease (CVDs), Deep Learning, Electrocardiogram (ECG), Convolutional Neural Network (CNN).

1. Introduction

The essence of this project is to design the automatic system that could help classify cardiovascular diseases by applying deep learning methods on ECG images. This system is designed to detect cardiovascular irregularities such as arrhythmia and myocardial infarction from ECG signals based on analyzing waveform shape and variation along with other image features of ECG signals.

This system will be applying concepts of deep learning in order to achieve correct pattern recognition and be highly scalable for additional data sets and classification of more diseases in the future. This application is intended to serve medical doctors for faster and accurate detection and interpretation of the condition reducing the effort and time required for manual analysis of ECGs.

2. Related Work

As cardiovascular diseases (CVD) remains one of the top killers all over the world, the requirements for the effective and accurate detection are tremendous. ECG signals, electrical activities from the heart, are widely used by medics to examine the performance of the heart, i.e. rhythmic and functional state. In the past, cardiologists or health care experts manually analyze and assess the ECG signals. Although they can give a high level of accuracy in interpretation of ECG signals, it necessitates highly skilled people, and becomes much laborious when there is huge amount of ECG signals to be analyzed. Driven by the digital health revolution, the accessibility of large medical datasets is enabling researches to find more effective automatic approach to diagnose diseases. Nowadays, the machine learning and artificial intelligence approaches have become the candidates for analysis of medical data, and for detecting patterns corresponding to various CVDs. Lots of research works on building intelligent systems for detecting the cardiac problems through analyzing ECG signals by using computational models has been produced. [1]

Early work on the detection of cardiovascular diseases used traditional machine learning techniques to analyze the ECG signals. SVM, KNN, Decision trees and Random Forest classifiers were

extensively utilized for the ECG signal classification problems. The common procedure in these methods was to extract specific features of the ECG waveforms such as the variation of heart rate variability, the duration of the P wave, the width of the QRS complex, variations in ST segment, etc., which are also known as hand-crafted features. The handcrafted features are fed into the machine learning model for ECG signal classification, dividing the ECG signals into two classes as normal and abnormal. While these methods can produce decent classification results, the performance is highly dependent on the quality and accuracy of the hand-engineered features. The hand-engineering features require good signal processing and domain knowledge, which make the whole system more complicated. With more complex and larger ECG data sets the limitations of these methods became obvious and other methods capable of learning features automatically without the need of expert intervention came into the scene. [2]

The rapid developments of artificial intelligence have brought various effective ways to medical image analysis and healthcare applications, for example, deep learning methods are widely utilized as an effective technology in medical imaging analysis. Convolutional neural network (CNN) models are one of the most popular approaches in deep learning methods for they automatically learn hierarchical features from the raw data. For image analysis problems, the ability of CNN networks to recognize pattern like edges, shapes, and complex structure in the image is highly appreciated. CNN networks have been applied on the ECG signal analysis, researchers have developed and applied CNN architectures to classify the ECG signals and discover heart abnormality, which feed the images of ECG signals or ECG representations into deep learning models and CNN network will be able to learn complex data correlations that can not be easily captured by the human experts. Several research has applied deep learning model to accurately detect heart diseases such as arrhythmia, myocardium infarction and other

cardiovascular diseases. Deep learning models will replace manual feature extraction, increase speed of automatic diagnosis and be embedded into contemporary medical systems [3].

Beyond network architectures, studies also consider the role of preprocessing methods to enhance the performance of automatic ECG analysis. Raw ECG data in clinical environments typically contain noise and irrelevant disturbances originating from human movement, electrical interference or electrode artefacts. These artefacts cause the machine learning model performance to degrade if they are not filtered and eliminated properly. In this context, preprocessing methods such as noise filtering, signal normalization, or image size scaling are widely applied prior to feeding the input to a deep learning model to extract better data quality or consistent signal patterns that might contribute to increase classification performance. Some research also employs data augmentation to obtain diverse datasets and prevent models from generalizing. Preprocessing results in the feeding of a quality and meaningful input to a deep learning model which boosts the accuracy for classifying ECG signals to detect various cardiovascular diseases. [4]

Although significant progress has been made in the domain of automated ECG signal analysis, there still exist some limitations for the development of highly accurate and reliable diagnostic system. The quality of the recorded ECG signal varies depending on the patient condition. Medical data is not widely available in terms of labelled samples to train a machine learning model. Advanced deep learning architectures are now widely being experimented and refined for better performance with better training methods. Similarly, a deep learning based framework cardiovascular system is proposed to diagnose cardiovascular diseases based on ECG images. A CNN based architecture is used to automatically extract significant features from the patterns of the ECG signals and classify the same in normal or abnormal categories. Combining efficient preprocessing techniques with feature extraction in deep learning framework, a better diagnosis can be performed. It can aid in early detection of diseases, medical decision-making, and make cardiovascular healthcare services much more efficient. [5]

3. Objective

This project primary goal is to create a reliable and automatic system for detecting the cardiovascular diseases using ECG images and deep learning technologies. Cardiovascular diseases is the first leading death in the world, so an early diagnosis and a suitable treatment may prevent them to get worse. It is desired to analyze the ECG signals and extract features which can recognize heart diseases, such as Arrhythmia, Myocardial Infarction, etc. In this project a CNN model is used to extract feature implicitly, classify the different types of heart conditions. At the same time preprocessing methods such as noise canceling, normalization and resizing the images will be used in order to improve the data quality. The system is expected to reduce the manual effort and the time needed by doctors to diagnose the patients based on ECG images.

4. Proposed System

Our proposed method is an automated system for the detection of cardiovascular diseases from ECG images with using of deep learning approaches. The proposed system uses a CNN model for analyzing the ECG signals in the images, detect the abnormal heart beat patterns, and classify the common or abnormal ECG signals with their specified disease. The system first collect the ECG dataset and performs the preprocessing processes which include the noise removal, normalization and resized the images then the cleaned ECG images have been used as the input values for the CNN network which contain the convolutional module, fully connected layer and pooling layer. The multiple layers will extract significant features in the ECG signals, identify the significant patterns and learn the clinically useful features in the training phase. After the training, the network will classify the input images to the general categories for characteristic of the various diseases.

5. Architecture Diagram

The architecture designed for cardiovascular disease detection from ECG images by using

deep learning can be classified into the following steps: First the ECG data is collected and passed through the preprocessing stage, where the noise, removal and image resizing and normalization are done to achieve high-quality images. The processed ECG images are then given as an input to the Convolutional Neural Network (CNN) model where through convolutional and pooling layers for extracting features, then reducing dimensions, and fully connected layers for classification the model would take the ECG images and identify them as a normal or abnormal condition and thereby enabling the accurate and automatic disease detection.

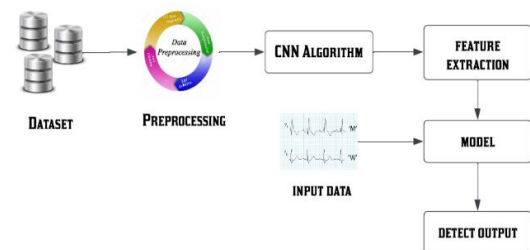


Fig.5.1: Architecture Diagram

6. Algorithm

This system applies the algorithm of Convolutional Neural Network (CNN) to classify the ECG images and diagnosis the cardiovascular diseases. CNN is a type of deep learning algorithm which is good for analyze images data, especially, to extract features automatically from the input images. In this method, the ECG signals are firstly transformed to images and input into many layers in CNN architecture. The convolutional layers use various filters to perform a convolution with the ECG images in order to identify important patterns in waveforms, like shape of ECG waves and fluctuation of signals. The characteristic features obtained by the convolutional layers will generate a feature maps. Pooled layers help in reducing dimension of feature map while retaining important information of the ECG signals, thus reducing the computation time. In the fully connected layer, the extracted features from previous layers can then be used for classification where the system is expected to predict a normal condition or a cardiovascular disease from the ECG image.

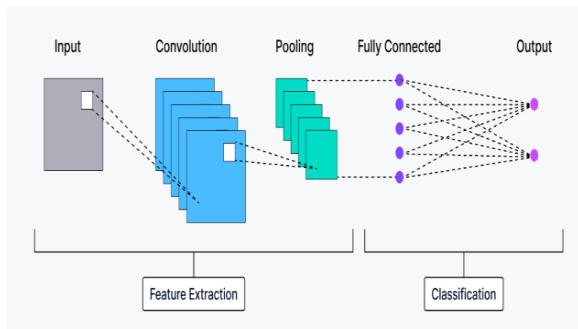


Fig-6.1: Convolutional Neural Network

7. Implementation

7.1 Data Collection and Preprocessing

The aim of this module is to gather and pre-process ECG data for the purpose of analysis. ECG images can be derived from a number of established medical data sources which have recordings of varying heart conditions. ECG data itself can often be corrupted with noise or unrelated changes so a pre-processing stage is implemented. In the pre-processing stage, noise is filtered, the data is normalized, and image resizing is implemented to create consistency within the dataset. Each of these processes effectively remove irrelevant signals from the image and magnify the relevant ECG waveform morphology. Appropriate pre-processing of the data is necessary because it creates an image which is in the correct form for a deep learning algorithm.

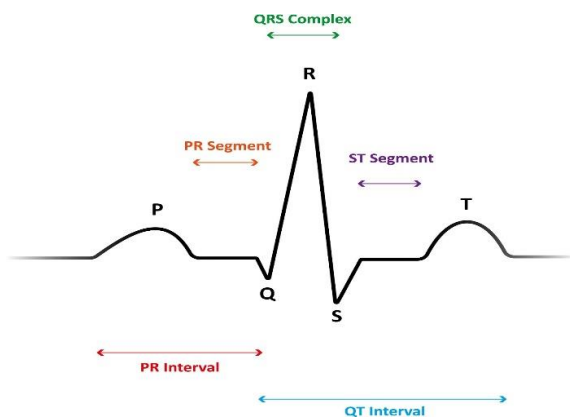


Fig-7.1: PQRST Complex in ECG Signals

7.2 Feature Extraction

This module involves selecting key features from ECG images using a CNN. The convolution layers used extract specific features from ECG images using various filters such as shape of waves and characteristics of signals. The extracted features are represented in feature maps where the required characteristics are expressed. The pooling layer reduces the size of the feature maps and important characteristics are preserved thereby ensuring focus on the relevant features to be classified. CNN automatic extraction avoids human feature engineering and enhances analysis of ECG signal.

7.3 Model Training and Classification

This module trains the CNN model to recognize the patterns of normal and abnormal ECG signals. The ECG images pre-processed into training and testing sets. In the training stage the CNN model recognizes the patterns of cardiovascular diseases by training its inner parameters to identify the corresponding patterns. Finally, it fully connected layers of the CNN network classify depending on the extracted feature. Predicting if the input ECG image will be a normal heart condition or a cardiovascular disease. Training, validation and testing are carried out repeatedly to achieve better accuracy and confidence in identifying the heart abnormalities.

7.4 Result Analysis and Disease Detection

In this module discusses evaluating the classification performance of the CNN and detection of cardiovascular diseases from the trained CNN model. Once the model process the ECG image and output classification result, then classify as 'normal ECG signal' or 'abnormal ECG signal'. The system performance would be analyzed using measures such as accuracy, precision, and recall. This type of automatic interpretation system provides rapid and effective heart disease detection. It could be a decision support system for the doctors that make diagnosis process efficient and simplify. The last module discusses evaluating the classification performance of the CNN and detection of cardiovascular diseases from the trained CNN model.



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8. Experimental Results

This section address the implementation of the system for detection of cardiovascular diseases ECG images by using deep learning approaches. and the figures below Fig. 8.1, Fig. 8.2, Fig. 8.3, and Fig. 8.4 present the user input and registration details necessary for uploading the patient ECG data. The final results will be displayed in Fig. 8.5.

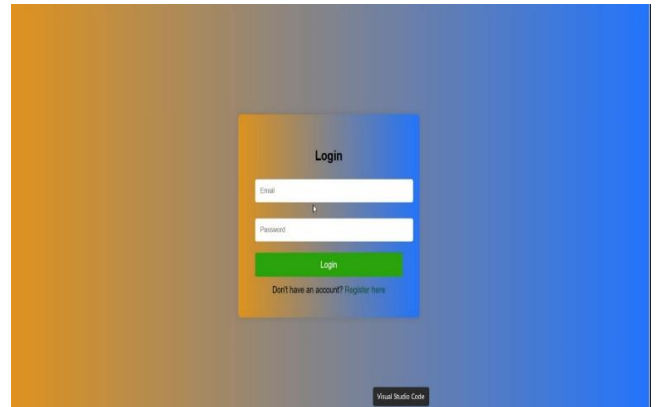


Fig.8.3. User Login

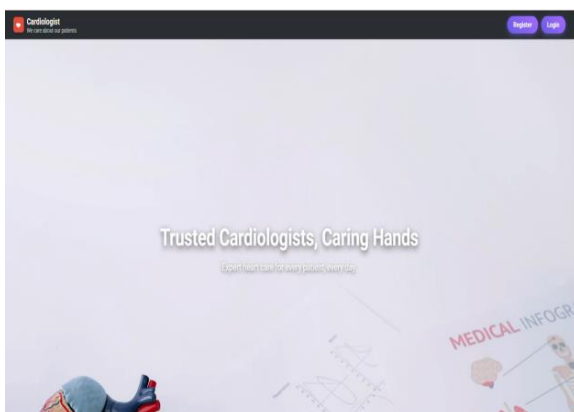


Fig.8.1. Application Frontend



Fig.8.4. User Input

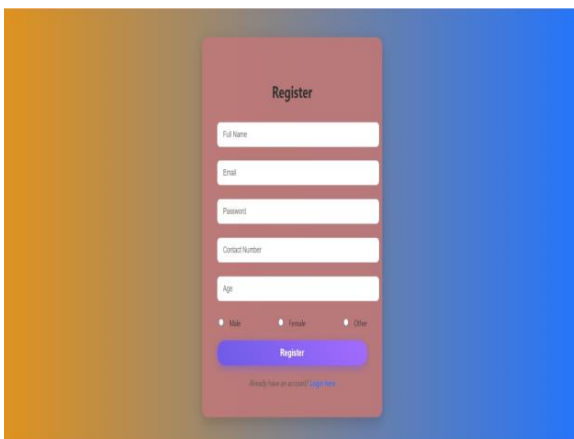


Fig.8.2. User Registration

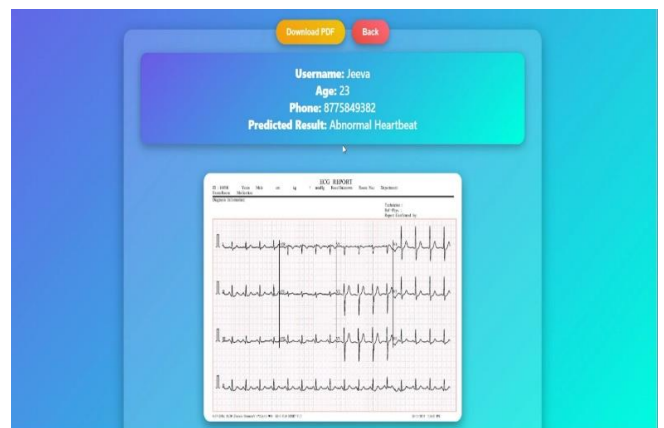


Fig.8.5. Output in Web Interface

9. Conclusion & Future work

We have presented a cardiovascular disease detection system, which helps diagnose the anomaly of the heart effectively using ECG images with the use of deep learning. We have used a Convolutional Neural Network (CNN) model to process ECG images and determine them as normal and abnormal. The system decreases the manual analysis time and complexity required for a medical professional to determine an ECG. It can analyze the ECG signals in an effective way, thus helping to diagnose the diseases of cardiovascular system. Future work on the system will include adding larger ECG datasets and more disease classes to obtain more accuracy in the model. Use of real-time ECG monitoring devices along with cloud medical systems will facilitate the continuous monitoring and faster decisions in the clinic.

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