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Cardiovascular Diseases Detection Using Photo Plethysmography (PPG) Signal Data

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Abstract

Photoplethysmography (PPG) signals have been widely used in clinical practice as diagnostic tools. In this article, techniques of machine learning have been used to improve the detection of cardiovascular disease (CVD) from the PPG signal data. Hypertension and stress are the main causes of the increase in blood pressure (BP), which in turn causes cardiovascular diseases. The treatment of patients, mainly those who have been suffering from CVD, resulted in an increment in the death rate. PPG is non-invasive, low-cost, fast, and simple to use. The signals of PPG are used for figuring out the anomalies in the cardiovascular system. By using PPG technology, cardiovascular parameters like blood pressure and heart rate are detected. This article investigates a machine learning and Deep Learning technique, which is Neural Network (NN), that has been used to assist physicians, this has achieved an accuracy of 98% by using the PPG-BP data set.

Keywords:

Photoplethysmography (PPG); Neural Network (NN); cardiovascular disease (CVD); Blood Pressure (BP)

Introduction

PPG has been demonstrated as a productive device for the quick diagnosis of disorders related to cardiac. By using PPG, the volume of blood fluctuations in the tissues has been measured. PPG serves as a promising technique for screening cardiovascular diseases. Circulation of blood from the heart to the toes is measured through PPG signals (Palanisamy, et.al, 2023). CVD causes leading death around the globe. The abnormalities of cardiac have caused 29.6% of death in worldwide during the year 2010 (Shabaan, M.,et.al, 2020)

PPG is more accessible potentially which requires less training for measurements in providing accurate insights in real-time (Weng, W. H., et.al,2023). In the paper, we will be investigating CVD prediction using the data from Physio Net (PN).

The data on blood pressure provides clear signals for scheming cuff-less blood pressure to estimate algorithms. The matlab files (.mat) which contain the raw electrocardiogram (ECG), photoplethysmography (PPG), and arterial blood pressure (ABP) signals are stored as cell arrays%20 of matrices.

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The purpose of this study is to enhance the classifier's performance in the detection of cardiovascular disease for PPG signals. The main purpose of this work is to compute the discrete cosine transform (DCT) for creating train and test sets by K-fold cross-validation. A classifier, linear regression, and neural network are used to pre-process PPG data. The effectiveness of the classifiers in recognizing the CVD from the PPG signal has been enhanced by the application of machine learning and deep learning approaches.

Methodology

The methodology used in this paper is explained as follows.

1. Data collection

The study's objective is to use a collection of subject features to distinguish between normal and diseased cardiovascular instances using the PPG signal.

2. Data Description

2.1 Age

Age is regarded as a major component that is closely connected to vascular stiffness and also has an impact on the PPG signal's form.

2.2 Gender

IT affects several bodily indications in people. According to Regitz-Zagrosek [4], men and women experience distinct CVD events including heart failure.

2.3 Height, Weight

This is used to the calculation of the Body Mass Index (BMI). They are the indicator of the overall health **2.4 Blood Pressure**

This is the key indicator for cardiovascular health. Any abnormalities in blood pressure, like hypertension, can easily indicate underlying cardiovascular issues.

2.5 Heart Rate

Changes in the heart rate can indicate abnormalities in heart function, they also indicate stress levels and physical activity.

3. Machine Learning and Deep Learning Classification Algorithm

K-fold cross-validation is a technique used in machine learning which helps in the Here we have used the Neural Network (NN) model which asses the PPG signal feature, by training this model on the dataset and predicting the likelihood of developing cardiovascular disease based on the PPG characteristics which is observed. The neural network is implemented using the framework known as TensorFlow.

Design Methodology

Detecting of cardiovascular disease step using PPG signal data involves a multi-process.

1. Data Collection

Data on patients have been collected, which includes details about gender, height, weight, blood pressure, and age. This helps in distinguishing between normal and abnormal cardiovascular cases.

2. Data Preprocessing

Preprocess includes reshaping the data, removing noises, and signal filtering which helps in analyzing the data without any disturbance. The overall process is depicted in figure 1.

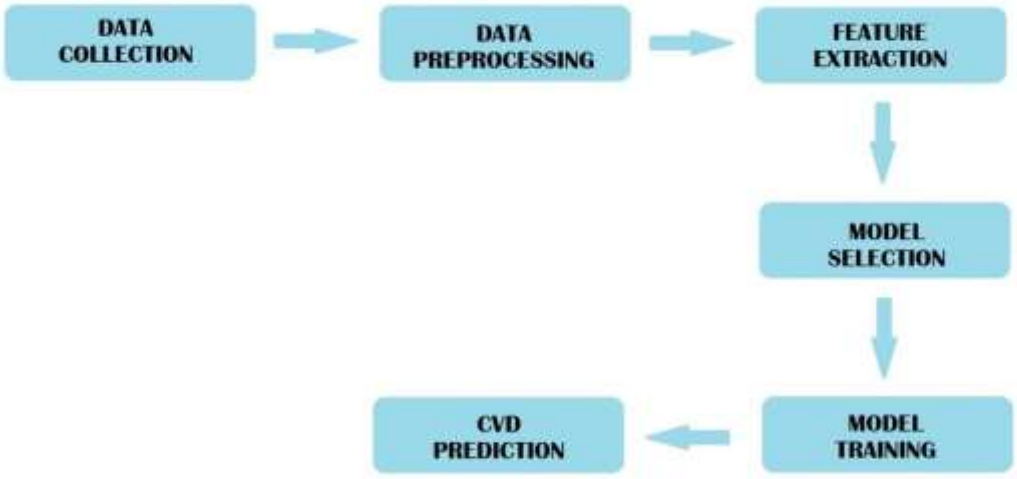

Figure 1. The schematic diagram for the implementation

3. Feature Extraction

Feature extraction that is cross-correlation has been done as they help in aligning and synchronizing the PPG signals, overall, they help in extracting the relevant information about the PPG signals related to the prediction of cardiovascular.

Discrete Cosine Transform (DCT) is used in the signal's compression, noise removal, and dimensionality reduction which in turn helps to improve the quality of signal representation and extract the relevant information for accurate analysis and detection the cardiovascular diseases.

4. Model Selection

K-fold cross-validation is a technique used in machine learning that helps in the model selection, this selects the model that performs best on average across the K iterations, K-fold cross-validation helps in ensuring the model that is developed is more reliable and effective in detecting cardiovascular disease using PPG signal data.

Here we have used a neural network model which asses the PPG signal feature, by training this model on the dataset and predicting the likelihood of developing a cardiovascular disease based on the PPG characteristics which have been observed.

5. Model Training

The model is trained with the data rows, For the speed purpose, which is to train the model on a subset of the training data.

6. Prediction

The neural network implementation framework known as TensorFlow has been used. After using the models and then visualizing the predicted result will be 98% accurate

Results

PPG is a promising technique for early diagnosis of cardiac disorders, measuring blood volume fluctuations in tissues, and detecting cardiovascular diseases (CVDs). PPG signals are used to measure cardiac functions, such as blood flow, heart rate, and mean circulation time. PPG signals can be spectral analyzed to identify variations in heart rate, overall to detect the changes in blood volume levels, PPG serves as one of the efficient non-invasive, and simple techniques (Prabhakar, S. K., et.al , 2019).

Blood pressure (BP) is a bio-physiological signal that provides vital information about human health. High BP is a significant health risk factor, leading to various diseases such as heart disease, stroke, and kidney failure. Accurate prediction and measurement are crucial for diagnosis, prevention, and treatment (Stojanova, et.al. 2019). The high quality of the PPG signals can be measured by placing the fingers on the PPG device, PPG signal will require only less hardware which is more prominent compared to the electro diagram (ECG) (Ramachandran, et.al, 2020).

Cardiovascular disease has become the more common cause to death, and efforts in an early detection approach are a very effective way of reducing CVD (Ave, Arrozaq, et.al, 2015). Many methods have been adopted for the merging of model behavior, among them the linear regression model along with the neural network model has been used to obtain the analysis prediction Li, Gen, 2018). The plan and the execution of the PPG are very simple and have simple support, the depth analysis in detecting the cardiovascular disease (CVD) is done with the help of the PhysioNet database (Rajaguru, et.al., 2023). Photoplethysmography (PPG) assesses cardiovascular function using infrared light in peripheral areas.

PPG is a non-invasive and inexpensive method for monitoring patient physiological conditions, making it suitable for pulse oximetry, The main aim is to optimize the output of cardiovascular disease by using the PPG signal data by achieving the accuracy up to 98% (Rabhakar, et.al 2020). Neural network is an algorithm for detecting CVD using PPG signal data. It extracts relevant features like heart rate variability and pulse transit time as input variables and uses a binary label for detection. Neural networks, particularly deep learning models, have shown promise in healthcare particularly CVD detection.

Denoising PPG signals improves clinical prediction, especially for cardiovascular disease (CVD) identification. This method is independent of clinical analytics and demonstrates the potential of physiological signal pre-processing, specifically denoising, for improved performance (Ukil, Arijit, et al., 2016).

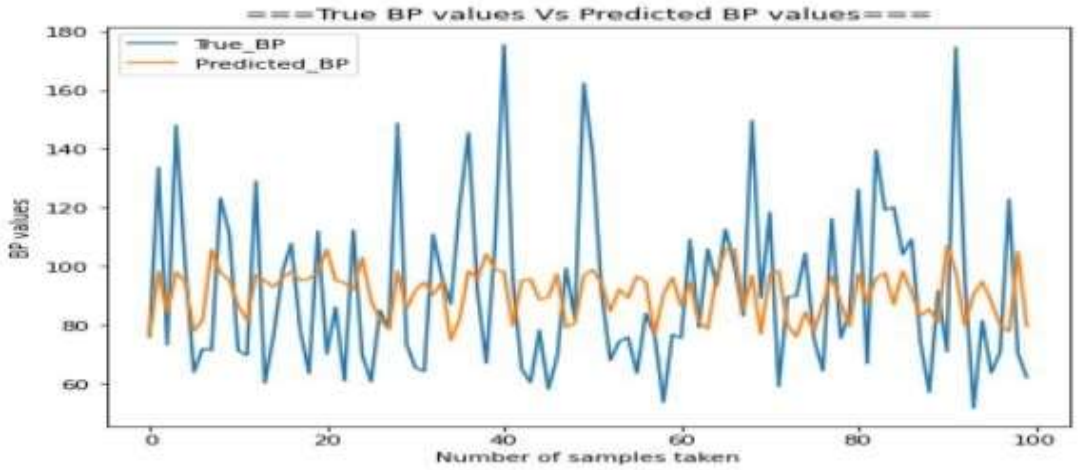

Figure 2. Visualization of Predicted values using linear regression

This visualization of Linear Regression compares the two set values and shows how the model's prediction align with the true values

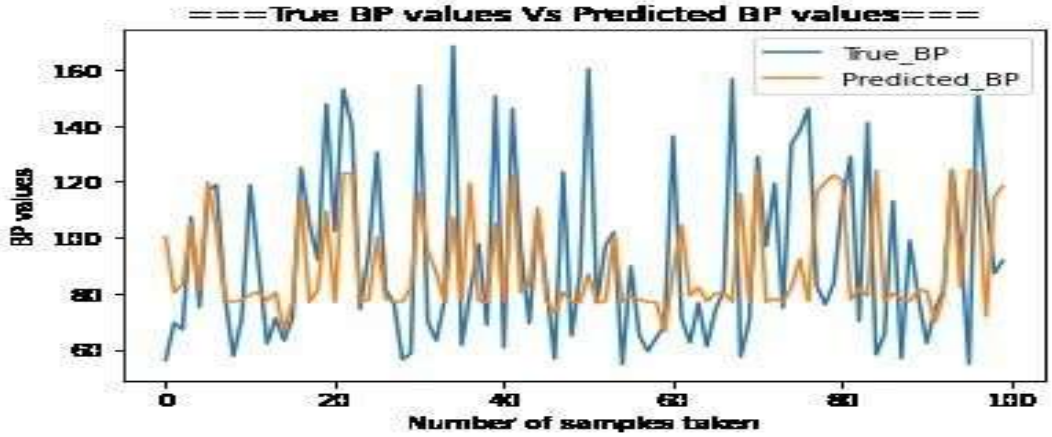

Figure 3. Visualization of Predicted BP and the true BP of Neural Network

This visualization compares the two set values and shows how the model's prediction aligns with the true values.

Conclusion

PPG signals have the potential to help in cardiovascular disease (CVD) detection and avoidance at an early stage, by monitoring vital signs and identifying abnormalities. By integrating machine learning algorithms, PPG-based systems can revolutionize cardiovascular healthcare, enabling timely interventions and improved patient outcomes. The project aimed to detect cardiovascular disease (CVD) using PPG signals. The datasets were stored as datasets and classifiers is used in classifying CVD with a high classification rate and low false positives. However, linear regression classifiers failed to achieve higher classification accuracy across all five dimensionality reduction techniques. A compromise was made by taking a segment of one-minute duration of raw PPG signals. The results showed high classification accuracy of 98% for neural network optimized values.

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