Extraction of R-Peak from Photoplethysmographic signal for diagnosis of cardiac diseases

R.Lakshmi Devi, Assistant Professor,
Department of Information Technology,
National Engineering College,
Kovilpatti, Tuticorin, Tamilnadu
lakshmideviit31@gmail.com

Dr.V.Kalaivani, Professor,
Department of Computer Science and Engineering,
National Engineering College,
Kovilpatti, Tuticorin, Tamilnadu
vkcse@nec.edu.in

Abstract—Wavelet transform are generally used for data denoising, compression, edge detection, etc. It is used for minimizing the noise in the signal. After wavelet decomposition, the high frequency sub bands contain most of the noise and a low frequency sub band contains most of the signal information. Noise is minimized by decomposing the PPG signals into a set of wavelet sub bands. Discrete wavelet transform (DWT) provides sufficient information for analysis and synthesis of the original signal with significant reduction of computational time. In DWT the signal is passed through a high pass filters and through a low pass filters to analyze the high frequencies and low frequencies respectively. Here Photoplethysmography (PPG) signal is considered for analysis. PPG is used to detect volumetric changes in blood in peripheral circulation. Noise is one of the major challenges because it may lead to produce the faulty PPG signal. In this paper, wavelet transform is used to remove the noises in the PPG signal. For denoising different daubechies wavelet filters were applied. Among them db5 gives better denoised signal. Denoised Signal helps to extract the features of PPG signal to diagnose the cardiovascular diseases.

Keywords—PPG, Cardiovascular diseases, wavelet, DWT

I. INTRODUCTION

Healthcare is an important issue to be addressed in India. It is a growing concern among people to have a check on their health status themselves. This issue has to be addressed with many continuous health monitoring devices which have to be economical, portable, reliable and easy to operate even by a normal individual. This gives a chance to improve the healthcare facilities in more rural places where advanced equipment is not an option.

Cardiac diseases are the major problems in our body. Different heart diseases that affected the human are congestive heart failure, cardiac arrest, heart valve diseases etc... The cardiac diseases need to be diagnosed earliest as possible. For that we need healthcare devices which are cost effective and portable for the earlier diagnosis of cardiac diseases. Mostly the diagnosis of heart diseases is done by the Electrocardiogram(ECG) analysis. To make the healthcare device cost effective and portable, Photoplethysmographic (PPG) signal is proposed.

PPG signal also have an important role in the diagnosis of cardiovascular diseases. The features of PPG signal are extracted to diagnose the diseases. PPG is often obtained by using a pulse oximeter. PPG can be acquired at the index finger. The PPG signal shows the blood movement in the blood vessels. The fig 1 shows the PPG signal viewed in MATLAB.

Blood Pressure (BP) is the force of the blood contained by the arteries. It is created primarily by the contraction of the Cardiac muscles.
Blood pressure is measured or recorded by two numbers. The first, Systolic Pressure, is measured when the heart contracts which is highest. The second, Diastolic Pressure, is measured when the heart relaxes or expands and is lowest. Blood pressure is a significant parameter in monitoring a patient’s health condition. It is an indication of various cardiovascular conditions, which makes it an important medical research or clinical parameter.

The features of PPG signal are Systolic Amplitude, Peak to Peak Interval, Pulse Interval, Pulse Width, Pulse Area and Augmentation Index.

PPG signals are vulnerable to motion artifacts, which strongly interfere with HR monitoring. Noise in the PPG signal is the main factor in the processing. The noises in the PPG signal affect the extraction of features, and hence the diagnosis of diseases. The major noises in the PPG signal are Powerline Interference, Motion Artifact, Low Amplitude PPG signal.

Power line interference is 50Hz or 60Hz noise from power lines. The amplitude of power-line noise is very large. This can be due to instrumentation amplifiers. Motion artifact can be caused by poor contact to the fingertip photo sensor. Baseline drift can be caused by variations in the temperature and bias in the instrumentation amplifiers. Low amplitude PPG signal can be caused due to bad connectivity between fingertip probe and the finger and loss of central blood pressure.

II. RELATED WORK

The PPG technology has been used in a wide range of applications for measuring blood pressure, oxygen saturation and cardiac output, assessing autonomic function and also detecting peripheral vascular disease [1]. PPG is easily detected at the index finger; it is feasible to rapidly evaluate the elasticity of the peripheral artery of diabetic participants using the PPG waveform [2]. Eduardo Gil et all [3] investigate whether the PPG can serve as a surrogate technique for the ECG in HRT analysis and finally concluded this as true. Zhilin Zhang [5] used PPG-based heart rate monitoring in wearable devices for fitness tracking and health monitoring.

III. METHODOLOGY

The main objective of the paper is to extract the feature of PPG signal. The PPG signal has several features. They are Systolic Amplitude, Pulse Width, Peak to Peak Interval, Pulse Area and Pulse Interval.

A. Systolic Amplitude

The systolic amplitude is an indicator of the pulsatile changes in the blood volume. In fig 2(a), X is the amplitude of systolic peak and Y indicate the amplitude of diastolic peak.

B. Pulse Width

The pulse width in the PPG wave is shown in Fig. 2(b). The pulse width is calculated at the half height of the systolic peak.

C. Pulse Area

The pulse area is measured as the total area under the PPG curve. Pulse area is shown in the fig.2 (c).

D. Peak to Peak Interval

The Peak to Peak interval is shown in the fig 2 (d). The distance between two successive systolic peaks will be calculated as Peak to Peak interval. The R-R interval in the ECG signal correlates strongly with the Peak-Peak intervals both represent a complete heart cycle.

E. Pulse Interval

The distance between the beginning and the end of the PPG signal is known as the Pulse Interval that is shown in fig. 2(d).

Among these features Peak to Peak Interval which closely correlated with the RR interval of ECG is extracted from the PPG signal. Before extracting the feature an important part of the work is noise removal. While acquisition of PPG, there are different types of artifacts and interferences such as Power line interference, Motion Artifact and Low amplitude signal may occur. The main objective of feature extraction is to
obtain the most appropriate information from the original data. The Process is described in the block diagram fig 3.

The process of extraction of RR interval begins with the collection of PPG signal. The PPG signal is acquired from the Physionet database. The noise in the PPG can be removed by the wavelet filter. After removal of noise from PPG signal, the features are extracted.

Wavelet transform is a linear transform that decomposes a PPG signal into several components at different scales. Wavelet transform are generally used for edge detection, data compression, de-noising etc. Here, wavelet is used to minimize the noise. After wavelet decomposition, the high frequency sub bands contain most of the noise components and a low frequency sub band contains most of the signal information.

After denoising the signal, find the peaks of the denoised PPG signal. The R-Peak detection was implemented in MATLAB. MATLAB stands for Matrix Laboratory. It is also used as a programming language for various applications of image and signal processing. It is a high-level language and interactive environment. This can be used in a wide range of applications such as image processing, signal processing, communications, control design and computational biology. The toolboxes extend the MATLAB environment to solve particular classes of problems in these application areas.

IV. RESULTS

The implementation was done in MATLAB. The signal collected from Physionet database is shown in fig 4.

The noise is added to the original signal for pre-processing of the PPG signal. The Noisy PPG signal is shown in the fig 5.

After adding the noise to the signal, the signal is subjected to denoising process. The denoising is done by the wavelet transform. The denoised PPG signal and the R peaks located in the PPG signal by db2 wavelet are shown in fig 6.
The denoised PPG signal and the R peaks located in the PPG signal by db3 wavelet are shown in fig 7.

The denoised PPG signal and the R peaks located in the PPG signal by db4 wavelet are shown in fig 8.

The denoised PPG signal and the R peaks located in the PPG signal by db5 wavelet are shown in fig 9.

V. CONCLUSION AND FUTURE WORK

The major challenge in the heart disease diagnosis is the timely diagnosis and accurately identifying particular disease. Here the PPG signal is used for analysis of cardiac diseases. Before extracting the features of PPG signal, it is denoised using Daubechies wavelet transform. Different Daubechies wavelets were applied to the noisy PPG signal and analyzed. Among them db5 wavelet is suitable for better reconstruction of the signal. After noise removal, Peak to Peak interval which is the major feature of PPG signal is extracted and further applied for classification of cardiac diseases.

REFERENCES


