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Pre-processing ECG signals for smart home material application

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Abstract

Health monitoring plays a vital role with regards to early detection, prevention of any form of illness which will promote good health and overall, well-being of the people. Nowadays Smart home systems, IoT based monitoring systems, medical bracelets, Invasive/non-invasive medical sensors are widely used to monitor the physical health of the people. Electrocardiogram signals (ECG) which are used to access the electrical function of the heart. Proper monitoring of ECG signals will help us to prevent major heart illness. It also helps us to ensure the oxygen pumping ability of the heart which is very essential to maintain the required oxygen saturation level of the body. ECG recordings are in general prone to various type of noises. Turbulent ECG signals may also lead to wrong detection and evaluation. Thus, preprocessing of recorded signals plays a major role in health monitoring. This paper aims to denoise the ECG signals by using filters in an efficient manner. Performance analysis of the filters are evaluated by comparing the level of variation of the signal and the noise which is expressed in terms of SNR, Correlation coefficient (COR), Mean Absolute errors (MAE), Mean Square Error (MSE). Our preprocessing approach has been valuated using ECG signals from Physionet database.

Introduction

As advancements in the field of medicine declines the progression from chronic disease to disability, alarming disability will reduce, but milder chronic diseases will shoot up. Hence it has become crucial to oversee the health metrics of the people regularly. ECG signals are used as a primary evaluation technique to identify the physical disorders of the people. ECG monitoring is carried out as statistical models to determine the health condition of the persons [1]. They are one of the prominent biomedical signals used from the olden days [2]. These signals can be used as a measure to detect both physical and mental health of a person. Fig. 1. Fig. 2. Fig. 3.

As per the recent studies mental disorders like Anxiety, Depression and loneliness can also be determined with the help of features extracted from ECG signals. Anxiety levels of a person has been determined with the help of ECG obtained via wearable sensors [3]. Using the physiological feature of the captured ECG signal we will be able to quantify the response of anxiety of an individual [4].

Analysis of Heart rate variability obtained from ECG signals will also help to analyze distress, sluggishness through signal processing [5]. Fatigue detection system has also been designed with the help of features extracted from the ECG signals [6].Nowadays for remote monitoring of outpatient's medical practitioner are using ECG signals for their diagnostic purposes [7]. Machine learning algorithms embedded with ECG monitoring are used to detect stress levels of an individual [8]. ECG signals are used to examine the productiveness of EMG for stress sensing [9]. The ECG recordings gets contaminated because of various noises and distortions. The major noises are Baseline wandering (BLW), Powerline Interference (PLI), Motion artifacts, Electromyogram (EMG) noise [14].

The presence of artifacts will hide the significant information of the heart functioning [51]. Preprocessing of signals will help to suppress the noise and accentuate the original waves in ECG signals [52]. ECG is also primarily used in both mental and physical health monitor, we need to eliminate these artifacts for proper diagnosis [21]. Considering these factors, Denoising of ECG signals before extracting the required features has become a vital process. Hence in this paper we have aimed to design an approach to denoise the acquired electrocardiogram signal with the help of digital filters before extracting the required features for diagnosis.

Section snippets

Noises in ECG signal

The ECG signals will get distorted due to various noises during acquisition and transmission. Mainly the signals will be affected by biological and environmental noises. Biological noises can occur due to the movement of the person while acquiring or it may be due to breathing movements [17].

Related works

Various algorithms and digital filter techniques have been employed to remove the noise artifacts from the recorded ECG signal. As per the review conducted, Denoising of the ECG signal which are carried out using Daubechies wavelet has produced better signal to noise ratio when compared to the preprocessing done with Symlet wavelet [7].

Also, Discrete Wavelet transform provides a better frequency and time resolution [35]. For these merits DWT is preferred to suppress the baseline wandering in

Design of filters

The artefacts are removed with the help of the designed preprocessing approach. For the acquired raw ECG signal, Fast Fourier transform has been carried out to convert the signal to frequency domain. As per the review paper [37] the actual peak of the observed signals can be preserved to greater extent by deploying FFT to the acquired ECG signals. Daubechies DB4 wavelet has been employed to the acquired ECG signal to remove the Baseline Wandering. DWT has been applied to acquired noisy ECG

Results and discussion

The Baseline Drift has been removed with the help of Daubechies DB4 Wavelet Transform as shown in the figure.

Notch filters has reduced the powerline interference to a greater extent. The resultant window of the filter has been depicted below.

Butterworth high pass filters which suppress all the low frequency noise has also yielded a smoothened ECG signal as depicted below.

The Weighted window filter has produced an overall better performance output when compared to all other window filters in

Conclusion

This proposalaims to present the preliminary process of ECG signal preprocessing using filter designs. The design has been coded with the help of MATLAB functions. An overview of ECG acquisition and its waveforms has also been presented. The results of literature review have also been shared which emphasizes on the existing denoising methods and the performance metrics which are commonly used. Using the design of DWT, IIR Notch, Chebyshev and Weighted Window filter the crucial distortions like

CRediT authorship contribution statement

R. Bharathi Vidhya: Conceptualization, Methodology, Supervision, Validation. **S. Jerritta:** Visualization, Investigation, Software.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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