REAL TIME WIRELESS ECG SIGNAL-BASED HEART DISEASE PREDICTION SYSTEM USING HVD

Raja Krishnamoorthy\textsuperscript{1}, Siva Shankar. S\textsuperscript{2}, Pogu Vignan\textsuperscript{3}

\textsuperscript{1}Professor, Department of ECE, CMR Engineering College, Hyderabad, Telangana, India.

\textsuperscript{2}Associate Professor, Department of CSE, KGRCE, Hyderabad, Telangana, India.

\textsuperscript{3}B.Tech Scholar, Electronics and communication Department, CMR Engineering College, Hyderabad, Telangana, India.

Email: krajameae@gmail.com

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Abstract

In this paper, ECG signal-based heart prediction system using HVD is proposed for continuous cardiac health monitoring applications. This proposed work consists of four blocks 1) ECG signal sensing from human body 2) uploading ECG signal to MATLAB 3) ECG signal analysis 4) SQI and disease identification. Wireless ECG system is built by using AD8232 module and HC-05, electrical activity is taken from it and transmit it wireless to the USB to TTL via HC-05, all the live signal is saved in the form of matfile. In ECG signal analysis, raw signal is filtered by using HVD and it find RR intervals and QRS complex. In SQI it will check whether signal is good, or diagnosis based on RR interval and QRS complex. If the condition is diagnosis it goes for disease identification, if any disease is identified all the data in form matfile is sent as email to doctor. The main motto is to design electronic T-shirt for continuous cardiac health monitoring. This system has enough potential for assessing biomedical diagnosis system.

Keywords: Electrocardiogram (ECG), Hilbert vibrating decomposition (HVD), Signal quality index (SQI), Universal serial bus (USB), Transistor transistor logic (TTL).

I. Introduction

For monitoring a continuous health through IoT ensured ECG was presented in [X], where the authors addressed a new signal quality aware system and validated all the test outcome with the consideration of MIT-BIH dataset. In [IV], authors presented classification-based biometric system using ECG signal of authorized candidates or users. They assumed one normal and couple of abnormal ECG data for testing the system with autoregressive modeling. Authors in [XI] addressed a study on various ECG DE noising approaches and ECG signal-based user identification.
system. Further, they provided a quality evaluation with the consideration of SNR and MSE parameters. A system for easier and efficacious acquisition of ECG signals from various patients was presented in [VI]. This system composed of various devices like MSP430, ADS1291, and CC2541. Retrieval of ECG information from charts and graphs with a digital computer and optical scanner was presented using morphological operations in [XII], where authors eliminated the noise in background and rendered the clean ECG from the paper accurately. Several feature extraction methodologies were addressed and presented in [I], where authors utilized some medical statistical parameters like accuracy, predictivity, and sensitivity for comparison. Later, An algorithm that extracted mixed features from an ECG was proposed in [XIV], where linear discriminant analysis with multiple features are utilized to resolve the issue of time-overhead, which usually occurs in training of large datasets. An Android-based ECG monitoring system that employs MSP430 was presented by J. Chai [V]. R. N. Mitra et al., [XI] presented a PC-assisted system performance assessment for identification of heart disease. Besides the feature extraction, authors implemented the algorithm for identifying a deviation in cardiac axis and further diagnosis based on the presence of LBBB or RBBB. In [II], authors presented a discrete wavelet transform based solution for identifying mankind by extracting P segment, QRS segment and T segment from the ECG signal. Due to the multiresolution analysis property of wavelets, this approach provided good accuracy. B. Liu et al., [III] developed a kind of portable ECG health monitoring system, which can make real-time acquisition about ECG information in the high degree of portable, reduce the patients’ psychological pressure with not to be restricted on the use scene, and implement a daily ECG healthy monitoring. In [XIII], authors discussed the techniques proposed earlier in the literature for noise removal, feature extraction and classification of ECG signal. Fully integrated SoC Neuromodulation system for Wearable review and implementation of health problems and a spike detection, low power ECG signal processor to be designed [VII, VIII].

II. Proposed Work

This paper intends to implement a project which analyzes ECG signal and detects whether any disease is identified, or the condition of the person is normal.

- It is explained by 4 blocks which are:
  1) ECG signal sensing (TX module)
  2) Uploading ECG signal to MATLAB (RX module)
  3) ECG signal analysis
  4) SQI and disease identification

**ECG Signal Sensing (TX Module):** Consider the electrical activity from the body which is the input through the AD8232 sensor is connected to Arduino. This acts an ADC sends the obtained digital output to HC-05. The digital information is then transmitted wirelessly to USB to TTL logic.

**Uploading ECG Signal (RX Module):** HC-05 and USB to TTL logic acts as a master to slave configuration. The digital information is given to Arduino as an input.
The Ardunio resembles as a hardware support package to the MATLAB in the digital information is shown as real time ECG Graph. Before the process enters into the third block the ECG signal is recorded for 10000 samples by a for loop condition. This obtained samples are saved in the form of mat file (ex-save ecg1.mat) which is a matrix configuration. The saved matfile is loaded as the data which starts the ecg signal analysis.

**ECG Signal Analysis:** This is the most pivotal part of the paper, where we analyze the ECG signal in the following steps.

**Removing Baseline Wandering:** Baseline wandering occurs during exhalation at frequencies ranging between 0.34 and 4 Hz. it can be reduce by high pass digital filter. This baseline wandering can be erased using method wavelet transform.

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**Fig. 1:** Block diagram of proposed work
Fig. 2: Flow diagram of proposed work

**Signal Pre-Processing**

**Algorithm for HVD Filtering**

**Step1:** function used in HVD filtering  
 x - initial signal, n - number of decomposed components

**Step2:** selecting maximum and minimum no of components  
if n>7-{Max number of components not greater than 7}  
if n<=0-{Number of components less than 1}

**Step3:** Smoothing the signal  
**Step4:** Angular Frequency lowpass filtering (Smoothing)

High frequency noise signal can be efficiently eliminated using process of wavelet transform. This paper follows Db6 wavelet because it largely represents real ECG signal. sampling duration of ECG signal in this paper is kept as 90 seconds and there are 23700 sampling points. hence wave decomposition is opted. We are using function `wrcoef`-reconstruct single branch from 1-D wavelet coefficients, based on the wavelet decomposition structure [e,f], at level N [e,f] represents filtered output.
Where \( e \) denotes total signal and \( f \) is no of levels decomposed. When compared with DWT process which attained smoothing in 8th level, HVD achieved the smoothing of the signal in 3rd level approximate signal from original signal which undergoes wavelet decomposition output signal will be filtered signal.

**Algorithm for Remez Hilbert transform with Filtering Procedure**

**Step 1:** selecting length of data and cutoff frequency  
**Step 2:** 90 degree - phase forward and reverse digital filtering  
**Step 3:** subtracting 10\(^{th}\) level approx. signal from original signal  
**Step 4:** removing glitches to increase the performance of peak detection

In this paper, An ECG signal with baseline wandering of different amplitudes are taken to correct ECG signal. We have taken ECG signal recording at 100, 108, 121 sample–matfile with the help of ECG sensor. This method is to remove baseline distortion here we are checking whether which wavelet decomposition is better DWT or HVD (proposed method). In this experiment we are taking baseline corrected signal to match with real time ECG signal, and find the correlation between them and try to figure out SNR in DWT and proposed method. This reason we are going with HVD over DWT is we got approximate signal at 3\(^{rd}\) level of decomposition, where in DWT we got approximate signal at 8\(^{th}\) level of decomposition.

**Peak Detection:** In order to find out R peak values we have to notice the highest points in the ECG signal \( Th=0.45*\text{max}(hh) \). Threshold setting at 45 percent of maximum value. To select highest point \((i=2:N1-1).length\) is selected for comparison\((hh(i)>hh(i+1)))\&(\(hh(i)>hh(i-1)\)\&(\(hh(i)>th))\). This is the condition in order to find the R peaks in the ECG signal.

**RR-Intervals:** RR-interval is nothing but the distance between two R peak points. It is further used in the calculation of average heart rate

\[
\text{RR-interval}=\text{time}(2:\text{end})-\text{time}(1:\text{end}-1)
\]

**Heart Rate Variability (HRV):** By using the RR-interval we can find BPM (or) average heart rate .the normal value of heart beat lies in the range of 60-100 beats /minute. Very slow heart rate indicates idio ventricular rhythm and low heart rate indicates bradycardia. high heart rate indicates tachycardia. If the QRS complexes are not evenly spaced an arrhythmia may indicates. if double QRS complex indicates atrial flutter. If BPM greater than 0.3 seconds, it indicates node blockage. The equation to calculate BPM is given below

\[
\text{BPM}=(1/\text{RR interval in sec})*60
\]

**QRS Complex Detection:** Duration of QRS complex is used in identification of diseases. First QRS complex is detected by identify the max peaks in the entire ECG location .max position is indicated as the R value and the immediate left value will be the Q and the immediate right value will be S value. Q value can be identified by using index value is subtracted from index-1 value must be greater than zero and count should increase if count is greater than 3 points than Q point is identified then plot the value of Q value. For the value of S ,same index value must be subtracted.
from its neighbour point it must be less than zero and count must be increasing and it is shown in Fig 2.8. If count is greater than 3 points S point is detected and duration of QRS can be calculated as $\text{Duration} = R - Q$

**SQI Algorithm:** The different steps are explained in Signal quality index. Fig 2.9 indicates the SQI algorithm steps.

**Viable Rules:** The first step of the SQI algorithm is to detect RR-interval and QRS detection. The following three rules are performed step by step, and if any is not satisfied, the sample is classified as

**Rule 1:** The Heart rate from 15-s sample must be between 60-100 bpm

**Rule 2:** The maximum gap between successive RR intervals are 3 s.

**Rule 3:** The ratio of the maximum RR interval to the minimum RR interval within the sample should be less than 2.2 seconds

**Rule 4:** QRS complex duration must be less than 0.1 second.

### III. Results and Discussion

Based on the BPM and QRS complex peak are required to identify condition of person. For that values we have added a sub function classifier to check the values of BPM and QRS duration. If the BPM is in between 60-100 and QRS duration is less than 0.1 sec. We can state that condition of person is NORMAL and its shown in figure 3.

![Output of real time ECG signal-based heart prediction system](image3.png)

**Fig. 3:** Output of real time ECG signal-based heart prediction system

![Transmission and Receiver sections](image4.png)

**Fig. 4:** Transmission and Receiver sections
BPM $\geq 60$ && BPM $\leq 100$ && QRS < 0.1

From the SQI algorithm we noticed that if the person condition has to be normal his RR interval must be $< 2.2$ and BPM should be in between 60-100. Fig 5 indicates the QRS complex peak value of normal person and result of normal condition.

Heart related diseases we identified which are listed below:

- Sinusbradycardia
- Sinus Tachycardia
- Ventricular achycardia
- Idio Ventricularrrhythm
- Wolf Parkinson White syndrome

**Sinus Bradycardia**: Sinus bradycardia is a slow heart rate disease if BPM is less than 60 and QRS complex is less than 0.1 sec person may affect to sinus bradycardia. The condition for sinus bradycardia is given below in Fig 6.

BPM $\leq 60$ && QRS < 0.1

Sinus bradycardia is a fast heart rate disease if BPM is in between 100-150 and QRS complex is less than 0.1 sec person may affect to sinus Tachycardia. The condition for sinus Tachycardia is given below in Fig 7.
BPM $\geq 100$ && BPM $\leq 150$ && QRS $< 0.1$

**Fig. 7:** QRS complex peak when person is affected with SINUS TACHYCARDIA

**Ventricular Tachycardia:** Ventricular tachycardia is a fast heart rate disease if BPM is in between 150-250 and QRS complex is greater than 0.1 sec person may affected to Ventricular Tachycardia. The condition for Ventricular Tachycardia is given below in Fig 8.

BPM $\geq 150$ && BPM $\leq 250$ && QRS $> 0.1$

**Fig. 8:** QRS complex peak when person is affected with Ventricular Tachycardia

**Idio Ventricular rhythm:** Idio Ventricular rhythm is a very slow heart rate disease if BPM is in between 20-40 and QRS complex is greater than 0.1 sec person may affected to Idio Ventricular Rhythm. The condition for Idio Ventricular rhythm is given below in Fig 9.

BPM $\geq 20$ && BPM $\leq 40$ && QRS $> 0.1$

**Fig. 9:** QRS complex peak when person is affected with IDIO Ventricular Rhythm
Wolf Parkinson White Syndrome: Wolf Parkinson white syndrome is a heart rate disease if BPM is greater than 60 and and QRS complex is greater than 0.1 sec person may affected to Idio Ventricular Rhythm. The condition for Idio Ventricular rythm is given below in Fig. 10.

\[ \text{BPM} \geq 60 \land \text{BPM} \leq 100 \land \text{QRS} > 0.1 \]

![QRS complex peak when person is affected with Wolf Parkinson White Syndrome](image)

Fig. 10: QRS complex peak when person is affected with Wolf Parkinson White Syndrome

IV. Conclusion and Future Work

Taking care about human life has been known heart disease is been important. ECG is the main method of diagnosis of heart disease. Purpose of the proposed work is that analysis of heart disease with real time ECG signal. This system is implemented by tiny hardware and MATLAB software and detecting the diseases based on RR intervals and QRS complex. Hilbert vibrating decomposition is applied for decomposed ECG signal. Db6 is used to shape QRS complex. Based on BPM and QRS complex duration we can determine the type of illness. for example BPM is faster than it is tachycardia. BPM is low it is bradycardia. These values are high in some patients data, if any disease is identified the data of MATfile is sent as email to diagnosis center. It is light weight, simple and low cost procedure for the diagnosis of various diseases which can be used in further study and education. This paper will reduce the workload of the doctors. It would be easier for doctor to verify later.

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