Virtual Environments Utilization for ECG Signals Analysis and Evaluation: Towards Heart Condition Assessment

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Abstract

The utilization of heart Electrocardiograms (ECGs) is to measure irregular heart rate and regularity and detection of an arrhythmia. Various ways are submitted and utilized for cardiogram feature extraction with a reasonable percentage of right detection. Although the problem stays open, especially with respect to superior detection accuracy in ECGs. In nature, The ECG signals are very sensitive signals, having voltage-level as low as 0.5-5 mv and frequency-elements fall into the range of 0.05-100Hz and the largest amount of the information received in the range of 0.05-45Hz. The recorded ECG signal includes various kinds of noises such as baseline wander, channel noise which becomes very critical to eliminating for the best clinical finding which assists in the patient. The utilization of the discrete wavelet transform (DWT) as wavelet transforms can be utilized to be a two-dimensional time scale process technique for feature extraction and classification task, therefore it's appropriate for the non-stationary ECG signals (because of the sufficient range values and the shift in a timely) in LabVIEW. To implement the feature extraction and classification tasks, a separating wavelet transformation (consonant), and the wavelet transform can be two-dimensional time-scale practical technique was utilized. Hence, it is relevant for non-constant ECG signals (because of sufficient scale-values and transformation in timely) in LabVIEW. The flexibility, standard nature and simplicity to utilizing programming possible with LabVIEW, makes it less complex. The pro-posed algorithm is executed in two steps. First step, de-noises the signal from the cardiogram signal to get rid of the noise, then detects the pulse, our extracted parameters are heart rate, P wave amplitude, T wave amplitude, S value, Q value, R-value, P offset location, P onset location, T onset location, T offset location and the location of P, Q, R, S and T wave.

Keywords: Electrocardiograph (ECG), Discrete Wavelet Transform (DWT), Heart Arrhythmia, LabVIEW Software.
1. Introduction

An ECG identifies cardiac-muscle-generated signals. A cardiac Rhythm cycle comprises wave segments P, QRS and T which identify the periodic depolarization and repolarization of the atria and ventricles utilizing a sequential method. QRS, as the most striking segment of the waveform implies specific importance for the cardiac interpretation of ECG signals. The embedded systems are adapted to perform an ambulatory ECG surveillance as a primary signal-processing device for irregular heart conditions detection by ECG signals evaluation with the semiconductor technology advancement,[1][2]. Detection ECG shows the heart data and the heart condition which is necessary to support the quality of patient living and suitable therapy. It is helpful and a very important tool within the heart disease description and a heart condition. Recently, many research and algorithms have been improved from the ECG signal analyzing and classifying. The features of ECG signals can be extracted in a time domain or in a frequency domain. Manual beat-by-beat measurements of all characteristic points in each lead are impractical in routine clinical observe. Especially for long term ECGs. For this reason, automatic ECG feature extraction Methods are more relevance[2][3]. Beat or QRS advanced detection is the most significant part which is Associate in Nursing ECG feature extraction system. Therefore, peak detection Algorithms are needed. Wavelet Transforms will show time vs frequency representation of the ECG signal and the non-stationary signals work well [4]. Wavelets also solve the existing short-time Fourier transform fidelity problem by utilizing a variable-length window. The large range of various wavelet functions supply an exclusive area to look for wavelet with efficiency represent an interesting symbol. [5][27]. Although there are some techniques available to select the better wavelets for an application. The orthogonal Daubechies wavelet family, specifically Db6 is utilized here [6]. We have enforced here the DWT to extract ECG signal features. The instrumentation in the ECG signals plays an important role, due to ECG signals are essential signals and are very small in amplitude provided by the human body [26]. High-gain with a high common-mode rejection ratio (CMRR) must be achieved. In the current research two electrical circuits have been studied, using the electronic components and different application components [7]. The application of LABVIEW is S/W from National Instruments that is designed particularly for simple and robust data collection purposes. Therefore, LABVIEW software was utilized to record and visualize the ECG data because of its big and known capabilities. The LABVIEW was utilized to implement a signal real-time filtering[8][28].
2. Methodology

The ECG signal is obtained using three lead system, i.e., Einthoven Triangle. The abnormality detection problem solution contains 4 vital parts. First stage is that the signal acquiring, here we have a tendency to utilize the ECGs signal within the system and gives it for analysis purposes to the program. The second stage is the raw ECG signal filtering in order to eliminate undesired noises. A third stage is the core stage, the signal feature extraction, i.e. through proper signal processing, ECG signals in terms of their parameters. The latest stage is the detection of various kinds of anomalies on the base of various values of the parameters received. The parameters are obtained in LabVIEW software where its features are known.

![Fig. 1, The Proposed System Flowchart](image)

Table 1, Shows The Normal ECG Waveform

| Normal Values for Amplitudes and Duration of ECG paraetres |
|----------------------------------------------------------|
| **Amplitude**    | **P wave** | 0.25 mV | **Atrial Depolarization** |
| **R Wave**       | 1.60 mV    |         |
| **Q wave**       | 25% of R wave |       |
| **T Wave**       | 0.1 to 0.5 mV | **Ventricular Repolarization** |
| **Duration**     |            |         |
| **P-R Interval** | 0.12 to 0.20 Sec |       |
| **Q-T Interval** | 0.35 to 0.44 Sec |       |
| **S-T Interval** | 0.05 to 0.15 Sec |       |
| **QRS Interval** | 0.09 Sec | **Ventricular Depolarization** |

A. Signal Amplification

The combinations of differential amplifiers are utilized to produce the received output from the noised input ECG signals which is obtained from bio-potentials that is called an instrumentation amplifier. In this proposed project we have utilized INA126 instrumentation amplifier. The amplifier for the instrumentation is usually the first point in the measurement system [9][10]. It is because very low voltages usually obtained from the probes need to be amplified. The ECG signals...
is too low and includes lots of additional noise. The signal extracted from the heart also has an amplitude of about 0.5 MV. Since amplifying the signal and removing the noise is necessary, and then extracting the QRS complex. The INA126 is utilized for low magnification. The gain of the amplifier is 13v/v [11][12].

B. Signal Conditioning
The Filtering circuit includes Bandpass filter with the non-inverting amplifier. In that, the frequency range of the Bandpass filter is 0.5-30 Hz and the Gain of the non-inverting amplifier is 100v/v. Thus, after the filtering stage noise will be removed and get the best signal of ECG[13]. After that, with the utilize of a summing amplifier, the signal has been summed in the range of 0-5v. There are many types of noises which are removed using this filtering technique such as power lines interferences, Electrodes contact noises, muscles artifacts, motion artifacts and baselines wander[14][25].

C. Summing Amplifier
The signal must be in a range of 0 to 5 volts, so that the signal will be converted from analog to digital form to perform analysis on it[15].

\[ V_{out} = \left(1 + \frac{R_f}{R_1}\right) \left(\frac{V_1 + V_2}{2}\right) \]

D. Data Acquisition
Analog to digital conversion is one of the most important things in the data acquisition system. It is basically performed using ADC0804[24]. Which is generally done in two ways: First, parallel mode where data is transferred at a faster rate with more the number of lines which is utilized for short-range data transfer and Secondly, in Serial mode where it utilizing one or two data lines which are utilized for longer range data transfer[16][17].
E. LabVIEW (Laptop)
A Virtual ECG Instrumentation is a various measurement system, that is very greater and flexible with the aid of computer intelligent resource[18]:

1. Continuous Wavelet Transform (CWT)
CWT is utilized to partition the function of continuous-time into wavelets. It is the input data sequence convolution with a set of functions produced by the mother wavelet. It is represented as[19][20]:

\[ W_s(a, b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t)h'(\frac{t-b}{a})dt \]

2. Discrete Wavelet Transforms (DWTs)
DWTs are utilized for both functional analysis and numerical analysis. Utilizing a set of filters is called the DWT of signal x. The sample is transferred via a low pass filter with the impulse response g which finds both parameters in a convolution [20][21].

\[ y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] \]

3. Feature Extraction
There are several features that can be derived from the ECG signal and all are unique in terms of heart rate and conditions. Before feature extraction, we have to remove the baseline wander and filter the noise present in the raw ECG signal. For this utilized VI is as follows[22][23]:

![Wavelet Detrend VI](image)

Fig. 3 Wavelet Detrend VI
Fig. 4, Eliminate Baselines Wandering and Wideband Noises

Fig. 5, Signal ECG with Multiscale Peaks Detection and Extraction Features
I. Finding and Discussion

This evaluation system was tested and validated on a few healthy subjects. Our extracted parameters are Heart rate, P wave amplitude, T wave amplitude, S value, Q value, R-value. The display window of our VI also gives the location of P, Q, R, S and T wave. It also gives the output value of P offset location, P onset location, T onset location and T offset location. Heart measurement is done by detecting the R-pecks which are detected by providing a threshold value to the ECG signal. If the signal is exceeded from the threshold value it will be counted as an R peak. We have put 0.8 MV threshold values according to the ideal peak value of R. In our analysis first, Wavelet detrend VI is utilized which removes baseline wander of the ECG signal. So, the output of this VI will remove the trend of the ECG signal. The Output of Wavelet detrend VI applies to the Wavelet de-noise. Transform type of Wavelet de-noise is UWT (Undecimated Wavelet Transform) with db02 and level 5, which de-noise the signal and wideband type noise. The output shows the smoother ECG signal and it displays sharp peaks. After filtering of the ECG signal, Each and every individual ECG superimposed on single ECG cycle and after overlapping of ECG signal we can get averaged ECG signal. The below table shows the feature extraction of acquired ECG signal from 10 healthy people.

Table 1, ECG Analysis and Feature Extraction Components

| No. | P-Wave Amplitude | Q Value | R Value | S Value | T Wave Amplitude | P Locations | Q Locations | R Locations | S Locations | T Locations | P Onset Locations | P Offset Locations | T Onset Locations | T Offset Locations | HR |
|-----|------------------|---------|---------|---------|-----------------|-------------|-------------|-------------|-------------|-------------|-------------------|-------------------|------------------|------------------|-----|
| 1   | 0.206            | -0.192  | -1.220  | 0.232   | -0.267          | 85          | 146         | 166         | 221         | 361         | 62                | 105               | 310              | 393              | 95  |
| 2   | 0.198            | -0.221  | -0.844  | 0.236   | 0.387           | 63          | 145         | 169         | 193         | 340         | 40                | 83                | 291              | 378              | 96  |
| 3   | 0.076            | -0.122  | -0.121  | 0.568   | 0.146           | 35          | 56          | 96          | 136         | 251         | 31                | 39                | 245              | 257              | 56  |
| 4   | 0.113            | -0.159  | -0.892  | 0.326   | 0.339           | 72          | 112         | 149         | 171         | 303         | 53                | 82                | 265              | 350              | 85  |
| 5   | 0.278            | -0.187  | -1.345  | -0.268  | 0.244           | 37          | 93          | 143         | 184         | 322         | 13                | 57                | 292              | 358              | 82  |
| 6   | 0.010            | -0.183  | -1.193  | 0.28    | 0.560           | 29          | 68          | 108         | 149         | 252         | 29                | 29                | 214              | 292              | 61  |
| 7   | 0.047            | -0.324  | -1.340  | 0.319   | 0.714           | 43          | 112         | 136         | 181         | 296         | 32                | 51                | 248              | 337              | 78  |
| 8   | 0.109            | -0.850  | 0.187   | 0.399   | 18              | 70          | 123         | 191         | 295         | 8           | 23                | 242               | 328              | 328              | 70  |
| 9   | 0.077            | -0.0161 | -1.147  | 0.553   | 0.284           | 42          | 96          | 122         | 140         | 290         | 27                | 52                | 242              | 322              | 70  |
| 10  | 0.289            | -0.251  | -1.173  | 0.442   | 0.186           | 58          | 116         | 141         | 189         | 401         | 37                | 66                | 394              | 403              | 82  |
Fig. 5, (a) Original ECG Signal Record No.# 111 (b) ECG Signal With Noise, (c) Reconstructed ECG Signal (De-Noising Signal)

Fig 6, (a) Noisy ECG signal Record No.# 122 , (b) Successful Extraction of R Peak wave under the baseline artifact
Fig. 7, (a) Raw ECG Signal Record No.# 113 , (b) Detrended ECG signal

Fig. 8, Original ECG Signal Record No.# 112 , (b) Overlapping ECG Signal
Analysis of heart rate variability of various subjects is shown in below figure 6.

**IV. CONCLUSION**

In the proposed work, the parameters were determined and calculated with high accuracy after completing the analysis of all ECG signals and utilizing those parameters are utilized to identify and validate cardiac defects those parameters are utilized to identify and validate cardiac defects. In addition, it has been checked for baselines wandering due to motion artifacts, so that the electrode movement does not result in inaccurate measurements. The research could therefore be a very economical tool, and much quicker than the current method. This is less expensive, far less time than without any specialist. So this methodology can be described as a system that saves lives. The various ECG signal parameters can be calculated, however, many advanced case structures could be utilized to search for more heart abnormalities with higher accuracies exploitation. The ECG patterns of various diseases utilizing the parameters found higher than they can be studied and analyzed to assist in the decision of higher cardiac algorithms. Only the ECG Signals have been targeted on software. Nevertheless, the system design can be generalized as a handy hardware design that a person can wear constantly and see the heart condition instantaneously.
Acknowledgment
This research is supported by the Department of Computer Science, College of Computer and Information Technology, Anbar University, and Sultan Idris Education University, Faculty of Art, Computing Creative Industry. We wish to express our gratitude to our "Dr.Ismail @ Ismail Yusuf Panessai at the "Faculty of Arts, Computing Creative Industry" for all of her diligence, guidance, encouragement and assistance throughout the work period. We would also like to express our sincere thanks to every person who has supported our project and the collection of data.

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