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ECG SIGNAL DENOISING USING UWT AND FEATURES EXTRACTION USING LABVIEW

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Abstract - *An Electrocardiogram (ECG) is a biological signal and non-invasive method to record the electrical activity of the heart by electrodes placed on the surface of human body. The raw ECG data are taken from MIT-BIH Arrhythmia database.*
In this paper firstly denoising can be done by using WA Detrend and Undecimated Wavelet Transform (UWT), which has the better capacity to reduce noise and better peak detection and then features extracted from the denoised ECG signal by using ECG Features Extractor VI, which are implemented with Laboratory Virtual Instrumentation Engineering Workbench (LABVIEW) platform.

Key Words: **ECG signal, Features extraction, LABVIEW, UWT, WA detrend, WA multiscale peak detection**

1. INTRODUCTION

The Electrocardiogram (ECG) is a non-invasive method for recording the electrical activity of the heart. Each heart beat is displayed as a series of electrical waves characterized by peaks and valleys i.e. P, Q, R, S and T. The ECG signal has frequency range of 0.05-100Hz and its dynamic range is 1-10mv. The standard ECG waveform is shown in figure 1

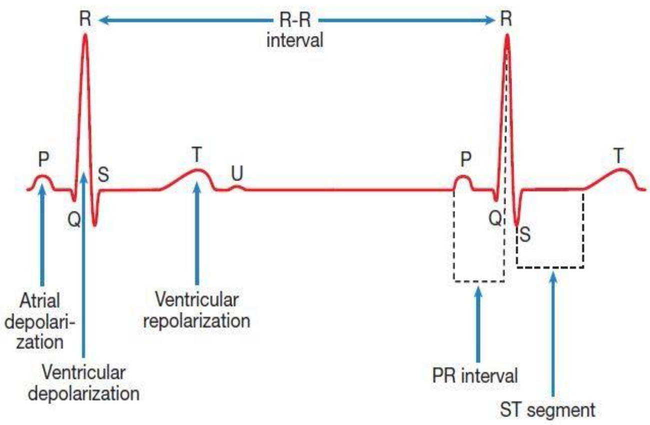


Figure-1 The Standard ECG Waveform

The human ECG signals are very weak and in milli volt range having frequency range 0.05–100 Hz with most of the useful information contained in the range of 0.5–45 Hz [2]. The parameters for normal ECG are given Table-I. If any ECG signal shows any deviation from the normal parameters of ECG it will indicate the disease related to it [3,4].

Table- I Normal ECG Parameters

Phase	Duration	Amplitude
P Wave	0.06-0.11	<0.25
PR Interval	0.12-0.20	
PR Segment	0.08	
QRS Complex	<0.12	0.8-I. 2
ST Segment	0.12	
QT Interval	0.36-0.44	
T Wave	0.16	<0.5

The recorded ECG signal contaminated by noise and artifacts, including:

- Baseline wandering
- EMG noise
- Motion artifact
- Power line interference
- Electrode contact noise

Among these the most significant are the power line interference and the baseline wandering which can strongly affect the ECG signal analysis. The baseline wandering (or trend) usually introduced from respiration and lies between 0.15Hz-0.3Hz.
The power line interference is a narrow-band noise centred at 50Hz (or 60Hz) with a bandwidth of less than 1Hz. To remove the power line interference, 50Hz notch filter is used [5,6].

The LABVIEW has the facility to read ECG signals from external files that can be downloaded from MIT-BIH Arrhythmia Database [1].

2. REMOVAL OF ARTIFACTS

The recorded ECG signal is contaminated by different noises. In order to draw out useful information from the noisy ECG signals, the recorded or raw ECG signals has to be processed. In the processing of ECG signal, denoising can be done by using wavelet transform. For removing the baseline wandering and other wideband noise, we can use the WA detrend VI and Wavelet denoise V I module in LABVIEW.

2.1 REMOVING BASELINE WANDERING

Baseline wandering usually introduced from respiration at frequencies wandering between 0.15 and 0.3 Hz. For suppressing it, a high pass digital filter is used. We can also use the wavelet transform to remove baseline wandering by eliminating the trend of the ECG signal.

2.1.1 Digital Filter Approach

For suppressing the baseline wandering we can use the Classical Filter Design. A Kaiser Window FIR high pass filter is designed in VI to remove the baseline wandering.

2.1.2 Wavelet Transform Approach

Apart from digital filters, the wavelet transform is also an effective way to remove signals within specific sub-bands. The LABVIEW ASPT provides the WA Detrend VI which can remove the low frequency trend of a signal [7]. WA Detrend VI as shown in figure 2

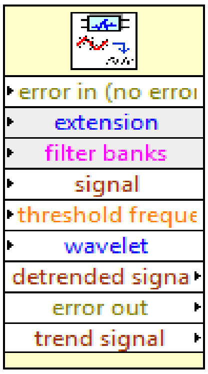


Figure-2 WA Detrend VI

The trend level is defined as:

$$\text{Trend Level} = \frac{\log_2(2t)}{\log_2(N)}$$

where t is the sampling duration and N is the number of sampling points.

Trend level specifies the number of levels of the wavelet decomposition [14], which is given as:

Number of decomposition level = (1-trend level)*log2(N) .

2.2 REMOVING WIDEBAND NOISE

After removing the baseline wandering, some other noise i.e. wideband noise affect the feature extraction of ECG signal. This noise can be removed by using the traditional filters. So Wavelet Denoise VI modu;e from LABVIEW can be used for this purpose [9]. Wavelet Denoise VI as shown in figure 3

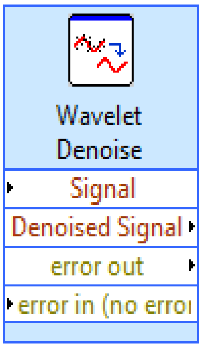


Figure-3 Wavelet Denoise VI

This technique firstly decompose the ECG signal into several sub-bands by applying a threshold function and finally reconstruct the denoised signal. In our work we can used the Undecimated Wavelet Transform (UWT) with soft thresholding.

2.2.1 Undecimated Wavelet Transform

The wavelet transforms are of two types: continuous and discrete. Because of its discrete nature, computer programs use the discrete wavelet transform (DWT). The main drawback of DWT is not translation invariant. UWT is used to overcome this drawback.
In our work we use UWT sym5 with single level and soft thresholding for wavelet denoising VI block setup. This setting of wavelet denoise technique perform perfect denoising on the recorded ECG signal without suppressing ECG features [8,9]. Thus, it produces more accurate information for the frequency localization.
The UWT is linear and shift invariant, redundant, more robust and less sensitive to noise. In biomedical signal processing techniques Hanning window is commonly used in narrowband applications.
Figure 4 shows the LABVIEW setup for ECG signal denoising and spectral measurement. To normalized the autocorrelation coefficients for dimensional reduction, the Fast Fourier Transform (FFT) is applied, so AC coefficients of

each ECG cycle is Fourier transformed and then the magnitude (peak), power spectrum is calculated [10].

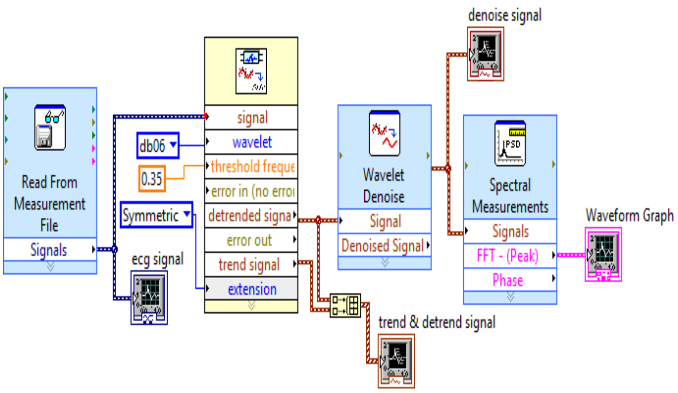
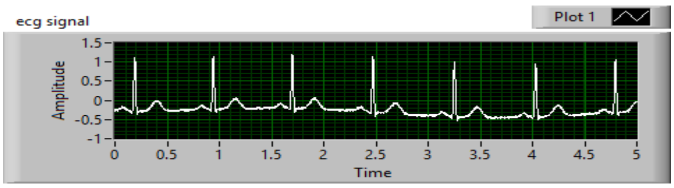
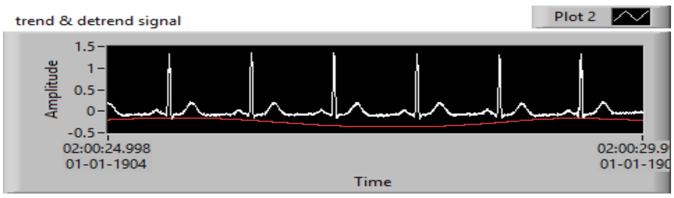


Figure-4 ECG signal denosing and spectral measurement

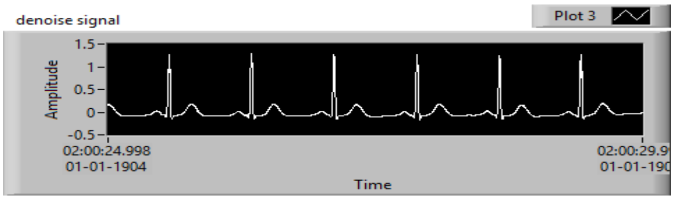
The ECG signal before and after denoising and the magnitude characteristics of ECG signal obtained using FFT is shown in figure 5.



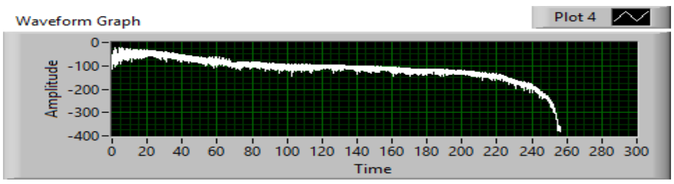
(a)



(b)



(c)



(d)

Figure-5 (a)Raw ECG signal, (b) Detrend signal, (c)Denoise signal, (d) Magnitude plot

3. FEATURES EXTRACTION

In this paper, the WA Multiscale Peak Detection VI in the LABVIEW ASPT is used to detect the P, R and T points. The ECG wave detection is centered on the R- peak extraction. All other waves of the ECG signal including T, P, Q and S waves can be easily located with reference to R-peak and with the assumption that wave intervals and segment durations are known as per table-1 [11].
After the peak detection the input data will be transformed into a reduced representation set of features i.e. features vector. Transforming the input data into the set of features is called feature extraction. Figure 6 shows the ECG signals processed by WA multiscale peak detection VI and features extraction of processed ECG signal.

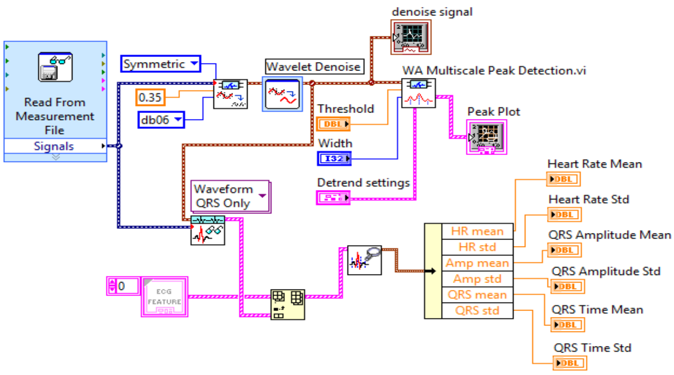


Figure-6 ECG signal with WA multiscale peak detection and features extraction

In our work we extract various features from the denoised ECG data, including heart rate, QRS amplitude, QRS time etc. The most prominent feature is QRS complex and the accurate detection of QRS complex is the basis for the extraction of other features [12,13]. The peak plot of denoised ECG signal and extracted features as shown in figure 7

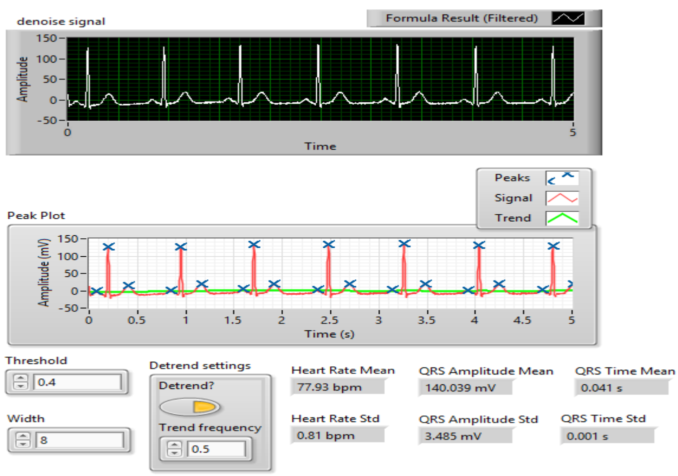


Figure-7 Peak plot and extracted features

3. CONCLUSIONS

We present in this the undecimated wavelet denoising approach applied to the electrocardiogram (ECG) signal. Using UWT wideband noises are strongly suppressed with all the details of the ECG signal are kept invariant. Our key idea was to remove baseline wandering and wideband noise that is corrupts the original ECG signal, peak plot and features extraction by an adequate processing with LABVIEW.
Future development can be made as follow: To design better feature extraction methodology which can improve the classification result of cardiac disorders in ECG signal.

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