Study of ECG signal using MATLAB and Wavelet

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Abstract—**This paper deals with the study of ECG signal processing by means of MATLAB tool effectively. The proper utilization of MATLAB functions (both built-in and user defined), toolbox and Simulink can lead us to work with ECG signals for processing and analysis both in real time and by simulation with great accuracy and convenience.**

Index Terms—**ECG signal processing; MATLAB; wavelet transform; ECG simulator; simulink.**

I. INTRODUCTION

Electrocardiogram is a diagnostic tool that measures and records the electrical activity of the heart in exquisite detail. Interpretation of these details allows diagnosis of a wide range of heart conditions.

An ECG is generated by a nerve impulse stimulus to a heart. The current is diffused around the surface of the body surface. The current at the body surface will build on the voltage drop, which is a couple of µV to mV with an impulse variation. Usually, this is very small amplitude of impulse, which requires a couple of thousand times of amplification.

A typical ECG tracing of a normal heartbeat (or cardiac cycle) consists of a P wave, a QRS complex and a T wave. The baseline voltage of the electrocardiogram is known as the is electric line. The is electric line is measured as the portion of the tracing following the T wave and preceding the next P wave. The electrical activity of the heart can be recorded at the surface of the body using an electrocardiogram. The electro-cardio-gram is simply a voltmeter that uses up to 12 different leads placed on designated areas of the body. Figure 1 shows the typical ECG trace [1]. The electrical activity of the heart is generally sensed by monitoring electrodes placed on the skin surface. The electrical signal is very small (normally 0.0001 to 0.003 volt). These signals are within the frequency range of 0.05 to 100 Hertz (Hz.) or cycles per second.
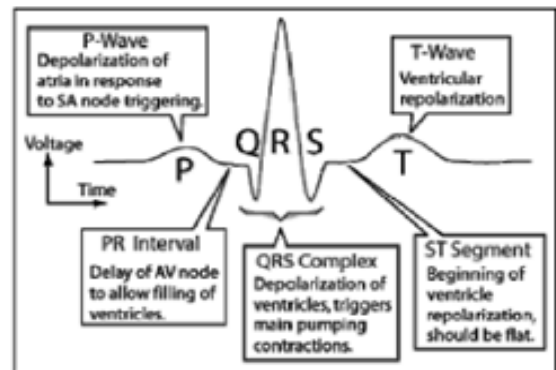

Fig.1. Typical one-cycle ECG signal tracking.

The ECG signals generated by human body are very low in amplitude. High gain must be obtained with high common-mode rejection ratio (CMRR). The ECG signals are very noisy, usually 50Hz noise, MATLAB was used to test and adjust a digital filter [2], in order to obtain a good QRS complex, which represents the ventricular depolarization in the ECG, i.e., it shows the electrical impulse of heart as it passes through the ventricles.

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II. ECG SIMULATOR

The ECG simulator produces the typical ECG waveforms of different leads and as many arrhythmias as possible. This ECG simulator is a MATLAB based simulator and is able to produce normal lead II ECG waveform [2], [3]. The use of a simulator has many advantages in the simulation of ECG waveforms. First one is saving of time and another one is removing the difficulties of taking real

ECG signals with invasive and noninvasive methods. The ECG simulator enables us to analyze and study normal and abnormal ECG waveforms without actually using the ECG machine.

A typical scalar electrocardiographic lead is shown in Fig. 1, where the significant features of the waveform are the P, Q, R, S, and T waves, the duration of each wave, and certain time intervals such as the P-R, S-T, and Q-T intervals. ECG signal is periodic with fundamental frequency determined by the heartbeat. It satisfies the Dirichlet's conditions. So Fourier series can be used for representing ECG signal. Each significant feature of ECG signal can be represented by shifted and scaled versions one of these waveforms as shown below.

Once we generate each of these portions, they can be added finally to get the ECG signal. So the generated output ECG signal by MATLAB is shown in Fig. 2.
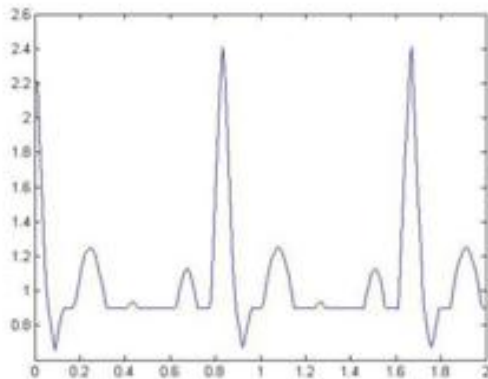

Fig. 2. Typical ECG output waveform simulated in MATLAB.

III. ECG SIGNAL ACQUISITION

In MATLAB, data acquisition toolbox provides Simulink blocks for acquiring live data into Simulink models and for outputting live signals to the physical hardware [4], [5]. It uses the *Analog Input* block to acquire live analog data from a data acquisition device into Simulink. The acquired data is processed in Simulink and uses the Analog Output block to output data to an analog data acquisition device. The acquired ECG data by Simulink is shown in fig. 3.
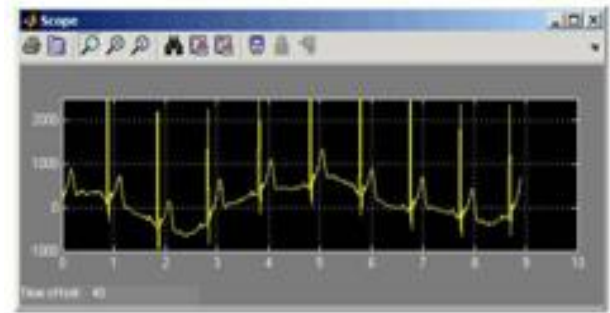

Fig.3 The simulink Scope shows an acquired ECG signal with sampling frequency 1000HZ.
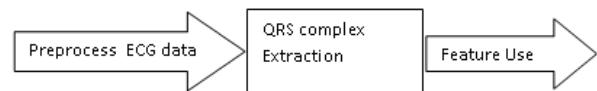
IV. ECG SIGNAL PROCESSING

The ECG signal is often contaminated by noise and artifacts that can be within the frequency band of interest and manifest with similar characteristics as the ECG signal itself.

ECG signal processing can be divided into two stages by functionality: preprocessing and feature extraction. The preprocessing stage removes or suppresses noise from the raw ECG signal and the feature extraction stage extracts diagnostic information from the ECG signal [5]. As an example, Fig. 4 demonstrates this functionality but also demonstrates an example where ECG data may be embedded within another ECG signal, such as a Fetal ECG signal.

Fig 4 ECG signal processing flowchart
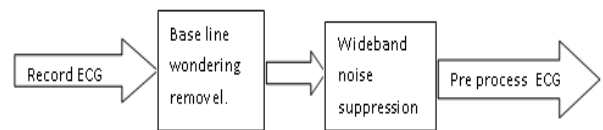
Feature extraction

Preprocessing ECG signals helps us remove contaminants from the ECG signals.

☐ power line interference

- ⬜ electrode pop or contact noise
- ⬜ patient–electrode motion artifacts
- ⬜ electromyography (EMG) noise
- ⬜ baseline wandering

The power line interference is narrow-band noise centered at 60 Hz (or 50 Hz) with a bandwidth of less than 1 Hz.

V. WAVELET TRANSFORM APPROCH

Wavelet transform is an effective way to remove signals within specific sub bands. It uses the Daubechies6 (db06) wavelet because this wavelet is similar to the real ECG signal. In this example, the ECG signal has a sampling duration of 60 seconds, and 12000 sampling points in total.

Figure 5 shows the original ECG signal and the resulting ECG signals processed by the digital filter based and wavelet transform-based approaches [6]. We can see that the resulting ECG signals contain little baseline wandering information but retain the main characteristics of the original ECG signal. It is also seen that the wavelet transform-based approach is better because this approach introduces less distortion than the digital filter-based approach.
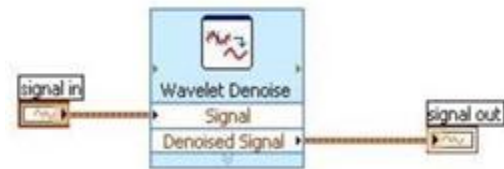

Fig :5 Removing wideband noise from ECG Signal by applying wavelet transform.

After removing baseline wandering, the resulting ECG signal is more stationary . However, other types of noise might still affect feature extraction of the ECG signal. The noise may be complex stochastic processes within a wideband, so you cannot remove them by using traditional digital filters. To remove the wideband noises, we can decompose the ECG signal into several sub-bands by applying the wavelet transform, and then modifies each wavelet coefficient by applying a threshold function. And finally reconstructs the denoised signal. The following figure shows an example of applying the wavelet transform (WT) to the ECG signal.
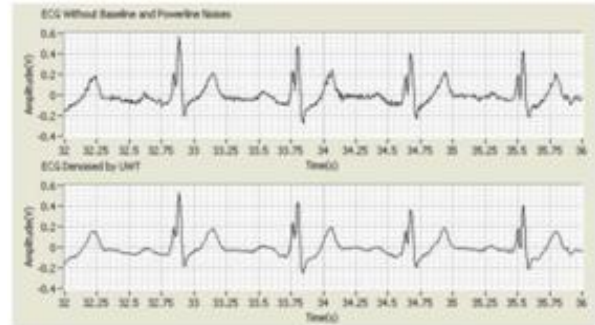

Fig 6: ECG signal before and after WT de-noising

VI. ECG SIGNAL ANALYSIS

ECG Signal is analyzed using built-in function of Wavelet Transforms to calculate the heart rate. The normal value of heart beat lies in the range of 60 to 100 beats/minute. A slower rate than this is called bradycardia (Slow heart) and a higher rate is called tachycardia (Fast heart). If the cycles are not evenly spaced, an arrhythmia may be indicated. If the P-R interval is greater than 0.2 seconds, it may suggest blockage of the AV node. The equation to calculate heart rate is given below.
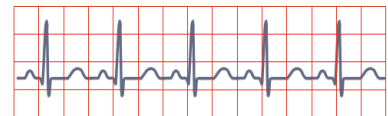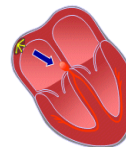
Heart rate = (1/ RR interval in sec.) * 60.
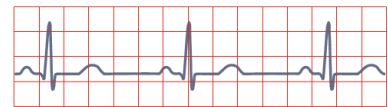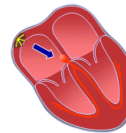
VII. CONCLUSION

MATLAB have immense effect on ECG signal processing. They are so useful and handy that even one can monitor his/her heart condition simply utilizing the power of MATLAB and without having an ECG machine and also self diagnosis is possible. All these examples and techniques that are discussed here can be really useful for experimental purpose even we don't have any ECG data we still can simulate and analyze it.

REFERENCES

[1] [1] A. K. M. F. Haque, H. Ali1, M. A. Kiber, and Md. T. Hasan, "Detection of Small Variations of ECG Features Using Wavelet," ISSN 1819-6608, *ARPN Journal of Engineering and Applied Sciences*, vol. 4, no. 6, pp 27-30, 2009.

[2] [Online]. Available: http://matlab-project-codes.blogspot.com/2010/08/algorithms-for-ecgs ignal-analysis.html

[3] [Online]. Available: http://matlab-project-codes.blogspot.com/2010/08/ecg-noisereduction. html

[4] [Online].Available:http://www.owlnet.rice.edu/~cmoran/ELEC301FINAL_POSTER_EEEEEEEEE.pdf

[5] D. Balasubramaniam and D. Nedumaran, "Implementation" of ECG Signal Processing and Analysis Techniques in Digital Signal Processor based System," *MeMeA 2009 - International Workshop on Medical Measurements and Applications*, Cetraro, Italy, May 29-30, 2009.

[6] C. Saritha, V. Sukanya, and Y. N. Murthy, "ECG Signal Analysis Using Wavelet Transforms"- *Bulg. J. Phys.* 35, pp. 68–77, 2008

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