DIFFERENT METHODS FOR ACQUISITION AND ANALYSIS OF ECG SIGNAL USING BIOMEDICAL SOFTWARE

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*Abstract :*This paper describes the various techniques used for automatic detection and analysis of electrical activity of heart using ECG. Electrocardiogram (ECG) is used for diagnostic purpose. Where, it is used for Diagnosing heart condition, fitness, regular checkup and many other diseases. If heart disease is not treated properly on time it may leads to cardiac arrest, arrhythmia, stroke and many other diseases. There are various method of analyzing ECG signals by detection of QRS complex, PR interval, R-R interval and ST segment.

IndexTerms-Electrocardiogram, Arrhythmia, QRS complex, Wavelet, MATLab, Heart rate, Signal processing

I. INTRODUCTION

As per recent study by the Registrar General of India (RGI) and the Indian Council of Medical Research (ICMR), nearly about 25 percent of deaths occur because of heart diseases [1]. Heart is the most important part of body where due to any irregularity in its functioning lead to various diseases so to overcome this issue we use electrocardiogram**.** Electrocardiogram is the technique which is widely used for diagnosis of heart parameter. Where in this technique we determine the electrical activity of heart by placing different kind of electrode over skin and this electrode detects minor change on surface of the skin due to heart muscles activity during depolarization and repolarization of heart.

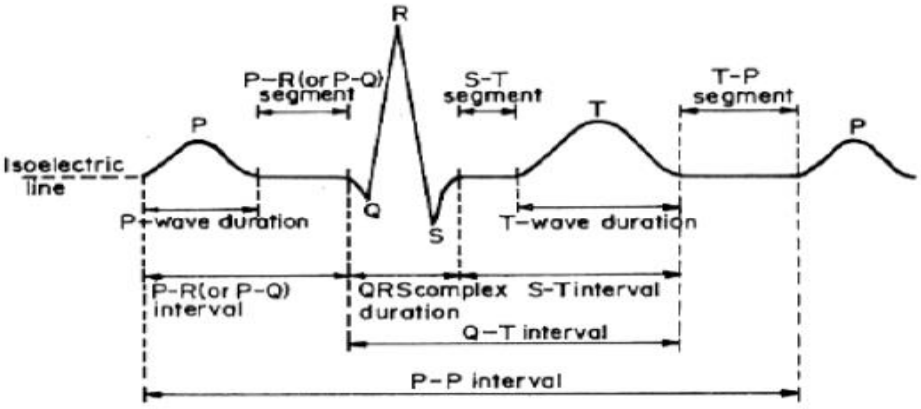

Fig .1 The normal ECG waveform [4].

To acquire ECG signal 12 leads and 10 electrodes are placed over chest where each lead detects different angle of activity of heart and over a time ECG waveform is obtained. This waveform is also known as PQRST waveform**.**Where, it has got different intervals and its own significance and they are as follows**:**

P wave: Identify the way of depolarization that spreads from the SA node throughout the atria [2].in this period depolarization of atrium take place. Time duration of P wave is 80-100ms**.**

PR interval: The time duration of this interval is 120-200ms. it represents the time between the onset of atrial depolarization and the onset of ventricular depolarization[2]**.**

QRS complex: It generates due to ventricular depolarization. Time duration of this complex is above 100ms and below 120ms**.**

ST segments:The ST segment connects the QRS complex and the T wave and has duration of 0.005 to 0.150 sec (5 to 150 ms) [3]**.**

S. No	Name of abnormality	Characteristic features
1	Dextrocardia	Inverted P-wave
2	Tachycardia	R-R interval < 0.6 s
3	Bradycardia	R-R interval > 1 s
4	Hyperkalemia	Tall T-wave and absence of P-wave
5	Myocardial	Ischaemia Inverted T-wave
6	Hypercalcaemia	QRS interval < 0.1 s
7	Sinoatrial block	Complete drop out of a cardiac cycle
8	Sudden cardiac death	Irregular ECG.

Table 1: Various abnormalities and their characteristic features [4].

II.METHODOLOGY

The System describes the main basic steps which are as follows:

2.1 ECG signal acquisition:

ECG signal for digital signal processing and heart rate calculation was acquired by measurement card with sampling frequency fs = 500 Hz. The first ECG lead was measured. Analogue signal pre-processing was done on simple amplifier circuit designated for ECG signal measurement. The circuit with ECG amplifier is fully described in [5].

2.1.1 ECG signal acquisition in MATLab:

The specifications are default for this signal which can be changed according to the user's requirement while simulating the MATLAB code. We take heartbeat as 72, amplitude of P, R, Q, T waves as 25mV, 1.6mV, 0.025mV, 0.35mV respectively while the duration of P-R interval, S-T interval, P interval, QRS interval as 0.16s, 0.18s, 0.09s, 0.11s respectively.

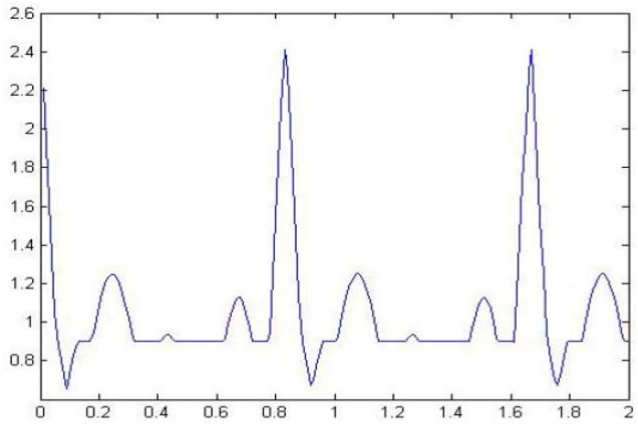

Fig. 2: Typical ECG output waveform simulated in MATLAB [6].

The Data Acquisition Toolbox provides Simulink blocks for acquiring live data into Simulink models and for outputting live signals to the physical hardware [7].

2.1.2 ECG signal acquisition in LabVIEW

With LabVIEW and related toolkits, such as the Advanced Signal Processing Toolkit (ASPT) and the Digital Filter Design Toolkit (DFDT), one can conveniently build signal processing applications for both stages, including baseline wandering removing, noise cancellation, QRS complexes detection, fetal heart rate extraction and etc [8]. In general, pure ECG signal is destroyed by the noise and other artifacts .so we can use noise removing techniques and different for attenuates and minimize that noise signals.

2.2 Removing baseline wandering

Baseline wandering usually comes from respiration at frequencies wandering between 0.15 and 0.3 Hz, and we can suppress it by a high pass digital filter. We also can use the wavelet transform to remove baseline wandering by eliminating the trend of the ECG signal [6].

2.2.1 Removing wideband noise

After we remove baseline wandering, the resulting ECG signal is static and clearly expressed than the original signal. The noise may be complex operation within a wideband, so we cannot remove it by using typical digital filters. For removing the wideband noises, we can use the Wavelet Denoise technique. In LabVIEW based higher-level first decomposes the ECG signal into several sub-bands by applying the wavelet transform, and then modifies each wavelet coefficient by applying a threshold or shrinkage function, and finally reconstructs the denoised signal.[6].

2.3 Digital filter approaches

There are two realization ways to realize Digital filter**:** one is the frequency domain method, using FFT fast algorithm of the input signal to the discrete Fourier transform, and analyzes its spectrum, and then based on the expected frequency characteristics of filter, finally reuse Fourier inverse transform time signal recovers. Another method is the time domain method; this method is based on discrete sampling data for difference numerical computation to achieve filtering purpose [9].

2.4 Wavelet transforms approach

Wavelet functions used for signal analysis are derived from the initial function W(t) forming basis for the set of functions for discrete parameters of dilation a = 2m and translation b = k 2m. Wavelet dilation, which is closely related to spectrum compression, enables local and global signal analysis [10].

$$W_{m,k}(t)=\frac{1}{\sqrt{a}}W\left(\frac{1}{a}(t-b)\right)=\frac{1}{\sqrt{2^m}}W\left(2^{-m}t-k\right)$$

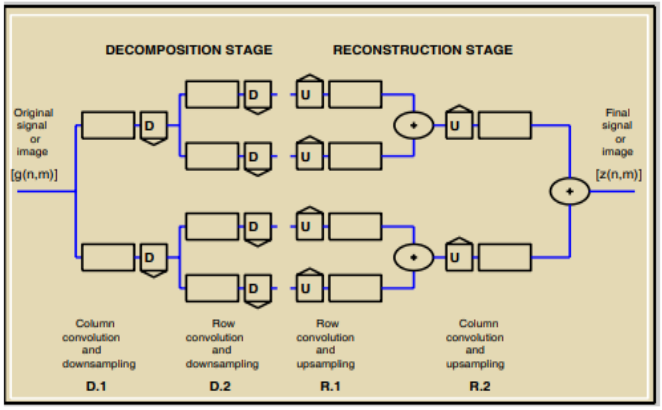

Fig.3: The principle of signal and image decomposition and reconstruction by wavelet transform [10].

2.5 QRS complex detection

The QRS peak is having an upside and downside curvature, a 20-sample average slope with respect to the midpoint of the FIFO stack will be continuously computed to capture the maximum value, with the objective of upside and downside slope of QRS peak. A probable QRS will be detected based on matching of a predefined threshold of slopes, and confirmed by comparing magnitudes of the samples to their neighbors [11].

$$slp_j = \frac{S_{i+j} - S_i}{j-1}$$

Where, slp_j = slope computed over a span of j-samples, ranging from i to i+j; S_j = magnitude of j^{th} Sample.

2.6 Heart rate calculation

ECG Signal can be analyze by built-in function of Wavelet Transforms equation to calculate the heart rate. The normal value of heart rate in the range of 60 to 100 beats/minute. A slower heart action than this is called bradycardia and a higher heart action is called tachycardia. When the P-R interval is greater than 0.2 sec, it suggest blockage of the AV node.

2.7 Feature extraction of ECG signal

Key Morphological features include Q, R and S detection, amplitudes and intervals [12], heart rate. After Reconstruction of the ECG signal, fourth level detail coefficients are extracted [1]. To find R peak positions, zero crossing detection of first order derivative of these fourth level detail coefficients is performed [1].

2.8 Abnormality detection

In the abnormalities detection phase, the abnormalities were divided into heart rate related abnormalities and general heart abnormalities and hence two different

A. Signal Pre-processing: Applied different type of filters and observe the effect of that filters on MATLab or LabVIEW.

B. Single Filtering: In this filter processing Butterworth filter is mostly used. Process depends on two parameter 1.cutoff frequency 2.order of filter.

C. Double Filtering: In order to assess the effectiveness of double or successive filtering, the signal filtered by the Butterworth filter was re-filtered by the FIR band-stop filter with the same parameters used previously in the single filter [13].

D. Filter Selection: To form the high efficient filter, the Signal-to-Noise Ratio (SNR) is used as evaluation tool assuming that the noise is additive. Each filter (single or double) was tested by this evaluation tool.

Formula for SNR calculation:

$$\mathrm{SNR_V} = \frac{RMS\ of\ Original\ Signal}{RMS\ of\ Noise\ Signal}$$

$$\mathrm{RMS} = \sqrt{mean(signal)^2}$$

III. CONCLUSION

By the review of the below papers and different features, it can be concluded that many different techniques can be used to detect heart abnormalities and heart disease by using different methods.ECG Is primary technique for heart diagnosis.Both MATLAB and LabVIEW give huge result on ECG signal processing. Different Noise removing techniques are present from that we can use that technique according to the noise and artefacts present in the ECG signal. Many tasks involved in signal analysis so that more accuracy is achieved and treatment is given before it is too late. There is scope for future research in each process leading to 100% accuracy. Results of MATLab implementations have shownthat the proposed ECG signal filtering and abnormalitiesdetection mechanisms can give a good indication of theunderlying physiological disorder.Traditionally, ECG arrhythmia classification relied on QRS detection and HRV analysis which produced accurate results though it relied on accurate ECG equipment which is not portable or wearable [14]. we can deduce that to remove the several noises i.e. channel noise, EMG noise, base line wander noise, wavelet transform techniques are found to be better than other techniques[15].The large assortment of ECG feature extraction algorithms, and the continuous efforts for their enhancement, proves that universally appropriate solution has not been found yet[16].

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