Examination of ECG Signal for Detecting Heart Stakes Using Signal

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Abstract: ECG is an example of the precise techniques used to analyze the heart and plays an important role in detecting the size of the blocks and determining the exact position of the blocks in the heart. In general, a random noise was superimposed on the signal by the signal produced using electrodes that converted physical energy to electrical signals. Signal noise is carefully extracted and it will be used to extract quantitative information from ECG signals, especially R-R peaks of the ECG signal to be restored by using Savitzky-golay filtering techniques and Walsh Hadamard transformation. After a FIR filter based on a freque ncy domain, extracted data is applied to obtain the precise values by measuring beat count and peak analysis o f R- R intervals. The approach proposed is to be stimulated by MATLAB and to be checked with the patient's ECG data signal.

Keywords: Savitzky-Golay filter, signal processing, transforming Walsh-hadamard, de-noising, ECG free spike.

I. INTRODUCTION

The heart's electrical activity is registered by an electrocardiogram (ECG). Automatic electrocardiogram analysis (ECG) has been the focus of extensive study over the past three decades and is well recognized in the field of bio-medical engineering. Its function as an important non-invasive investigative tool that provides useful information for the identification, diagnosis and treatment of cardiac diseases is of particular interest to the ECG analysis[1].

The ECG signal has a time periodicity that allows an elementary beat to be described, consisting of complex waveforms that appear periodically in time. The heartbeat and its respective waveform labels are shown in Fig 1. The foundation of ECG analysis is the study of the amplitudes and patterns of the waveform.

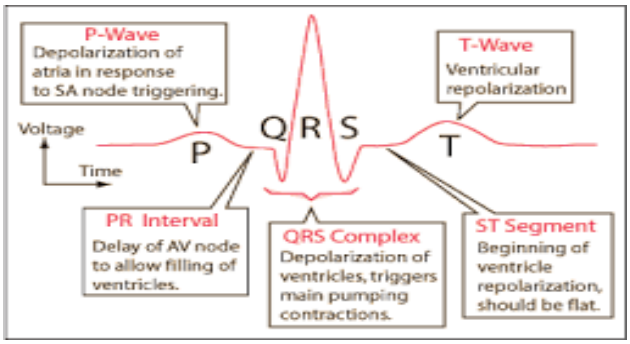

Fig 1.Heartbeat observed on an ECG with an elementary waveforms and intervals identified.

For instance, one can show that the heart rate is estimated after the detecting of QRS -complex from the beat sequence. In the same way the time-distance between the two consecutive QRS-complexes, known as R-R interval, is used to detect premature beats. We can extend this analysis to other conditions like ST segment deviation from a long period, necessary to early diagnosis ischemia. As a result, ECG analysis depends directly on the ECG beat segmentation results [1][2].Data obtained from the ECG signals pro-vides invaluable tools for diagnosing cardiac disorders. However ECG signals recorded from the Electro-cardiograph are usually corrupted by the noise attributed to several factors. To help solve these problems, Joseph Ackora-prahet.al [3] develop a simple but inexpensive and easy- to- implement MATLAB model that generates ECG and gives us mathematical control over the ECG signal. Our model fuses mathematical functions in MATLAB with psychological data Peter kovacs [4] presents an algorithm which generates realistic synthesis ECG signals, this algorithm, among others, can be used to testing the new methods in ECG processing. By using numerical and Geometrical parameters, which are diagnostically importance the generated signal can be interpreted as Bio medical signal with important diagnostically intervals such as QRS, QT, PR etc. On the other hand this method gives us a strict mathematical control over the signal.The details and importance of the ECG wave form given in the table 1.1 and1.2, based on this data the radiologist can estimated the of the heart of the human. The proposed method consist the simulation of generate of ECG wave in order to consideration of heart blocks.

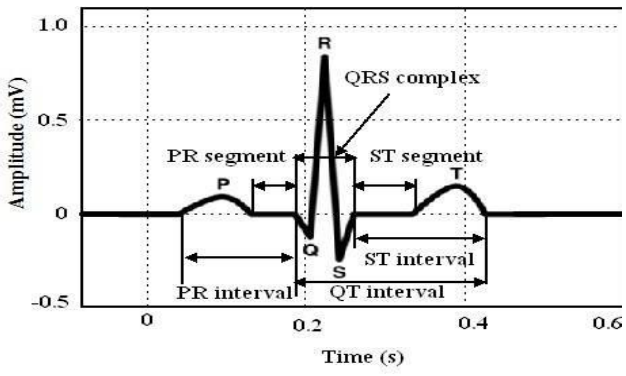

Fig 2 schematic representation of normal ECG waveform

Table 1.1.shows the features of P wave, QRS complex and T wave in amplitude and duration of each R-R interval is 0.4-1.2s.

WAVES	REPRESENTATION
P WAVE	The amplitude level of this voltage signal wave is low and represents depolarization and contraction of right and left atria clear P wave before QRS complex. Analyzing of p waves with a high signal-to-noise ratio in ECG signal.
QRS COMPLEX	The Largest voltage deflection of approximately 10-20 mV can be occur in QRS complex but may vary in size depending on age; gender.the voltage amplitude of QRS complex gives us the information on cardiac diseases. The time for ventricles may depolarize and may give information about conduction problems in ventricles, during the QRS complex.
T WAVE	It represents the ventricular repolarization.large T wave may represents Ischemia and Hyperkalaemia.

Table 1.2. Amplitude and duration of waves, intervals and segments [6], [7], [8] of ECG signals.

SL.NO	FEATURES	AMPLITUDE(mV)	DURATION(mS)
1.	P WAVE	0.1-0.2	60-80
2.	PR SEGMENT	-	50-120
3.	QRS COMPLEX	1	80-120
4.	ST SEGMENT	-	100-120
5.	T WAVE	0.1-0.3	120-160
6.	ST INTERVAL	-	320
7.	R-R INTERVAL	-	(0.4-1.2)s
8.	PR INTERVAL	-	120-200

II. NOISE IN THE ECG

Generally the recorded ECG signal is often contaminated by different types of noise and artifacts that can be within the frequency bands of ECG signal which may change the characteristics of ECG signal. Hence it is difficult to extract the information of the signal. The corruption of ECG signal can be occurring due to following major noises[12].

POWERLINE INTERFERENCES

Power line interferences contain 60 Hz picks up (in U.S) or 50Hz picks up (in India) because of improper grounding. And will appear as an additional spike at integral multiples of fundamental frequency[12]. Its frequency content is 50 Hz/60 Hz and its harmonics, amplitude is up to 50 percent of peak to peak ECG Signal amplitude. A 60 Hz Notch filter can be used to remove the power line interferences.

BASELINE DRIFT

Baseline drift may be caused in chest-lead ECG signals by coughing or breathing with large movement of chest, when an arm or leg is moved in case of limb lead acquisition [12].Baseline drift can sometimes caused by the variations in temperature and bias in the instrumentation and amplifier shown in the fig 3. Its Frequency ranges generally below 0.5 Hz. To remove baseline drift a high pass filter with cut-off frequency 0.5 Hz is used.

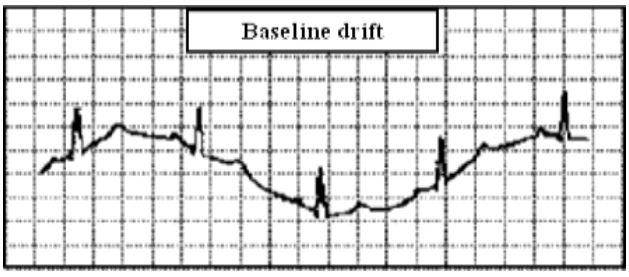

Fig 3. Baseline drifts in ECG signal

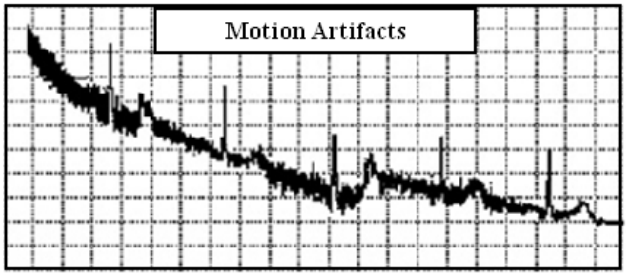

Fig 4. Motion artifacts of ECG signal

MOTION ARTIFACTS

Motion artifacts are transient baseline change due to electrode skin impedance with electrode motion. It can generate larger amplitude signal in ECG waveform shown in fig 4.. The peak amplitude of this artifact is 500 percent of peak to peak ECG amplitude and its duration is about 100-500 ms.An adaptive filter can be used to remove the interference of motion artifacts[12].

ECG NOISE

During the ECG recordings, the signal may be corrupted by the low and high frequency noise that alters the waveform of the ECG trace from its original structure. To eliminate the noise the most common types of noise and artifacts must be considered [5][12].

QUALITY MEASUREMENT: Extraneous noise in the ECG trace may be caused by a variety of noise sources including perspiration, respiration, body movements and poor electrode contact. The magnitude of the noise may be exceeding the amplitude of the QRS complex by several times, but its spectral content is usually confined to an interval below 1 Hz. .

ELECTROMYOGRAPHY NOISE (EMG NOISE): EMG noise is caused by the electrical activity of the skeletal muscles during the periods of contraction or owing to a sudden body movements.Although, the frequency components of EMG overlaps considerably with that of QRS complex, it also extends into the higher frequencies. As a result, the processing of ECG trace to remove these noises affects naturally results in some distortion of the signals.

III. MEASURING OF HEART BEAT

There are three simple methods to determine the heart rate (HR):

- The square counting method:

The square counting method is ideal for regular heart rates. Use the sequence 300-150-100-75-60-

50-43-37.count from the first QRS complex, the first thick line is 300, the next thick line 150 etc.Stop the sequences at the next QRS complex. When the second QRS complex is between two lines, take the mean of two numbers from the sequence or use the fine tuning method listed below:

- Use a calculator:

Count the small (1mm) squares between two QRS complexes. This method can works well for tachycardia, which is lower than 100 beats/minute. The ECG paper runs at 25 mm/sec through the ECG Printer; therefore:

Heart rate (beats/min) =300/ (number of squares)

- The marker method:

Non regular rhythms are best determined with the "3 second marker method". Count the number of QRS complexes that fit into 3 seconds (some ECG writers print this period on the ECG paper). Multiply this number by 20 to find the number of beats/minute.

IV. PROPOSED METHOD

ECG signal can be recorded by the electro cardiograph, which can generates the signal of ECG shown in block diagram fig.5. ECG signal with various conditions can also generate using above tables 1&2 data[]

BLOCK DIAGRAM:

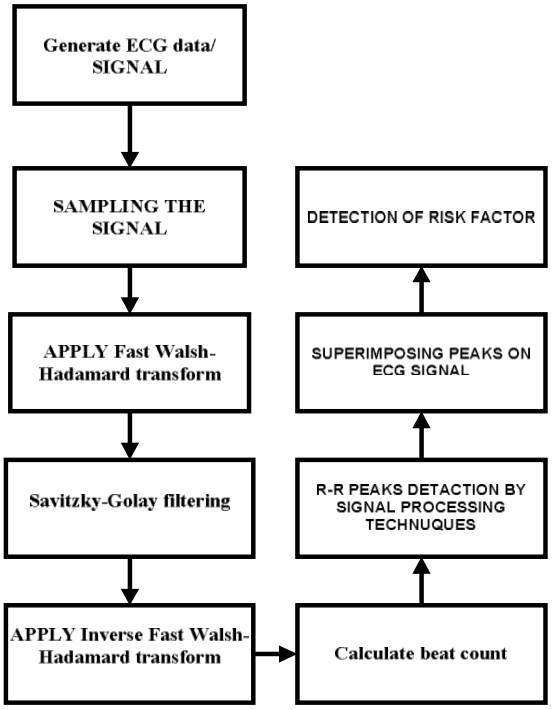

Fig 5. Block diagram of the proposed method of ECG Signal processing

That Generated ECG signal can be sampled with various sampling methods by using the high pass and low pass filters to remove unwanted samples. In our proposed method a compressed format of ECG signal has applied to process the signal. A walsh- hardmard transform is used to convert the ECG signal in frequency domain. The walsh-hardmard transform contain a +1,-1coefficents. Then a savitzky golay filter is applied to remove random varying values(Noise),

In general the filter can be chosen a odd number value then signal , which can also named as Savtizky-Golay filter and the denoising of the ECG signal.The sampled ECG data undergoes for the beatcount,to calculate the heart rate

i.e., heart rate (beats/min) = 300/(number of squares)

After calculating the beat count, The peak of ECG signal can be calculated by a signal process technique that is a FFT based FIR filtering process technique. In this process

undergone a continuous repeated operations until to get a R-R peaks above the normal values those peaks will super impose on the input ECG wave form. This waveform has give a information whether human heart have the blocks or he is in normal conditions.

the ECG after denoising can be superimposed on the original ECG signal. Further it can be used to detect the peak analysis, can various risk factors can be identified after the analysis of PQRST Complex waveforms. Finally the spike free ECG output can be obtained after filtering ,risk factor calculation, analyzing peak analysis, beat count measurement etc.

V. RESULTS AND EXPLANATION

It is output of original ECG signal which is obtained by giving default values in MATLAB coding similarly, different wave forms can be produced with different values. Figure 6 shows the complete signal input and this can be further processed for the filtration techniques for deducing the noise.

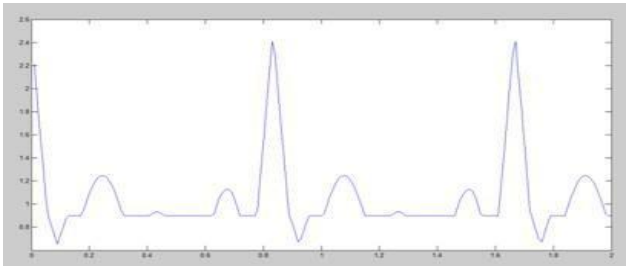

Fig6: Generated ECG signal

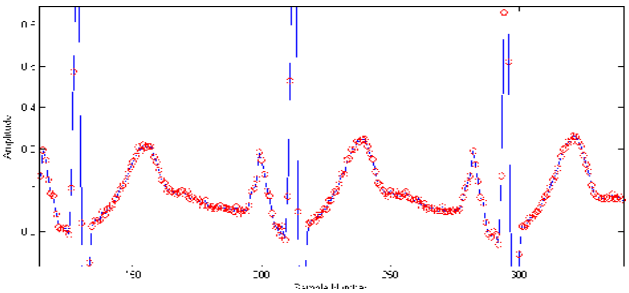

Fig: 7 sampled signal

The signal sampled by using a sampling process technique as shown fig 7. Then the wave form decimated with ecg as shown in fig 8.

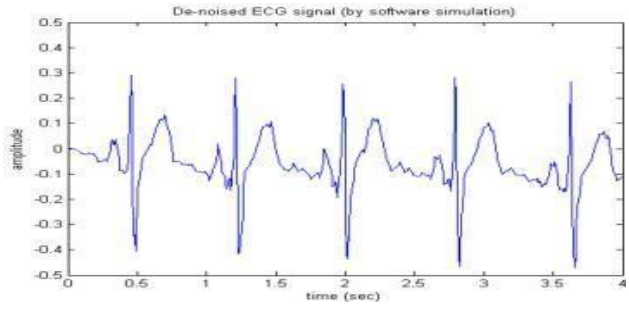

Fig7: Decimated ECG signal

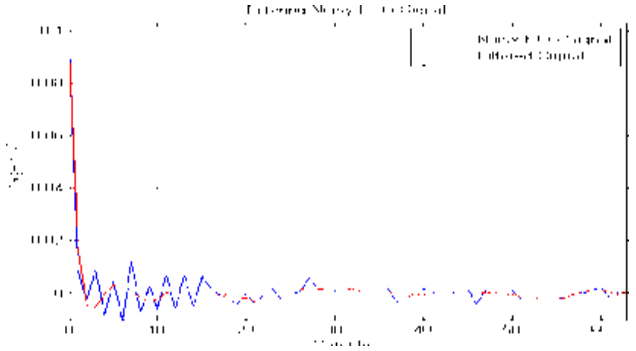

Fig: 8 spectrum comparison of noise, de-noise signal

It shows number of samples is reduced and the peaks is preserved, the signal applied de-noises process contains a Walsh hardmard transform, Sgolay filter. The output of the de-noise, noise wave spectrum is compared as shown in fig: 9.As one can see the ECG is uneven. Thus our first step is to straighten it. To say that in mathematical language, we should remove low-frequency component. The idea is to apply direct fast Fourier transforms FFT, remove low frequencies and restore ECG with the help of inverse FFT. Here is the result of FFT processing is to find local maxima. To do that we use windowed filter that "sees" only maximum in his window and ignores all other values. On this step we use window of default size, now we should remove small values and preserve significant ones here we are using a threshold filter. In this case the result is good but in general case we cannot be sure we have all the peaks. So the next step is to adjust filter window size and repeat filtering. Compare the result with fig.

10 which shows filtering quality is much better. It is final output which is ready.

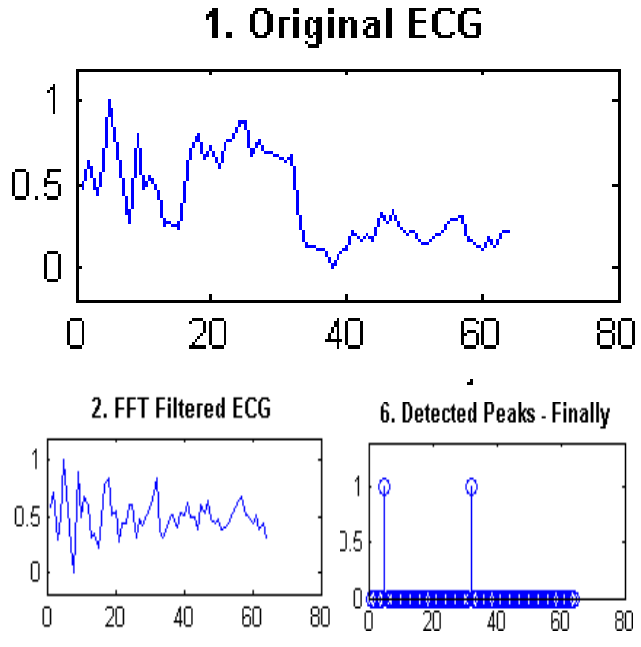

Fig: 10 Detection of peaks of the ECG signal

EXPERIMENTAL RESULTS ON R WAVE PEAK DETECTION:

Figure11: shows R Peak Detection The detection of R peak is the first step of feature extraction. The R-peak has a largest amplitude corresponds to other peaks.

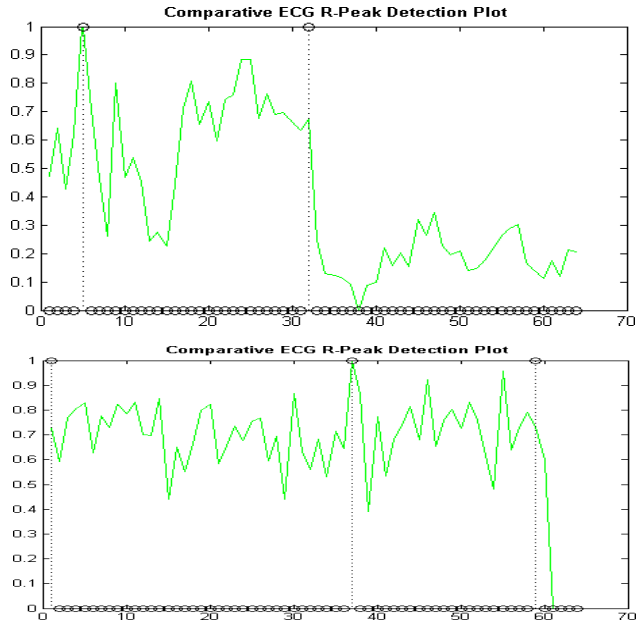

Fig:11a&b. superimpose the peak on signal

Hence amplitude of .5 has been taken as a threshold to detect R peak and finally we detect the R peak location and the difference between two R peaks is the R-R interval with reference to x axis. From the R wave detection we can calculate the heart beat .R peak is essential part in ECG wave .The high-resolution electrocardiography has become an important clinical tool for analyzing the high-frequency content of electrocardiograms (ECGs). Recent emphasis has been on the detection of ventricular late potential activity due to its ability to predict ventricular tachycardia (VT) in myocardial infarction (MI) patients. To accentuate the high-frequency components, the signal-averaged ECG data are filtered using high-pass filters. Two types of filters used in commercial systems, bidirectional Butterworth and Fourier transform filters, are compared using a common signal-averaged ECG data base. Signal-averaged ECG data acquired at two clinical sites (Mayo Clinic and Bowman Gray School of Medicine) using the MAC15 HIRES system were filtered using a 40-Hz fast Fourier transform (FFT) filter with a 6 dB/octave roll off on an IBM-compatible personal computer. The same average data were filtered using a 40-Hz bidirectional Butterworth filter with similar roll off. Using a common algorithm, outputs of both filters were used to compute vector magnitude and to obtain the measurements to quantify high-frequency, low-amplitude (HFLA) signals. The measurements include total QRS duration, duration of HFLA signals, root mean square voltage, and mean voltage in the terminal 40 msec. The results were very similar and both filters were found to be functionally equivalent.

VI. CONCLUSION

We have developed a ECG signal processing technique that employs with Walsh -Hadamard transform and Savitzky-Golay filter which were pre-processing the ECG signal generated from electrodes to be kept on human body. A windows based filtering process is applied to detect the peaks of the signal that is above the threshold value and also calculated beat count. The speed and accuracy of this approach depends on the wireless ecg and medium of data transfer. We are currently in process of applying this system to other repair procedures where traditional diagnostics have proven to be destructive.

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