A Broad Study on ECG Signal Noise Suppression for medical applications

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***Abstract*—The ECG a tool, which records the electrical activity of heart. Electrical signals from the heart generally precede the ordinary mechanical function and monitoring of those signals has clear medical significance. ECG is used in catherization laboratories, heart care units and for routine diagnostic applications in cardiology. Noise is an unwanted hassle to attain spike loose ECG signal. To cast off this problem we use various filters. In this paper we take an outline of all filters which do away with noise from ECG signal .Filter used like FIR, smoothing, Golay, Gaussian etc. In this paper we survey on all kind of filter out that's utilized in to acquire noise free signal. Removing motion artifacts from an electrocardiogram (ECG) is one of the crucial troubles to be taken into consideration at some stage in actual-time heart rate measurements in telemetric health care. However, motion artifacts are part of the temporary baseline exchange resulting from the electrode motions which might be the effects of a topic's movement. The work is based on digital signal processing (DSP) techniques with MATLAB package, as an extra work that allows us to achieve the goal of theme it will additionally be investigated and implemented for the elimination of harmonics (hum) and high frequency noise from ECG signal by way of the usage of smart notch rejection filters, which can be partial milestone for the project.**

***Index Terms*—Electrocardiogram (ECG), noise, filters**

I. INTRODUCTION

Today cardiac diseases and related failures are among the main causes of death in the world. Therefore it is necessary to have a proper method which determines the cardiac condition of the patient. Inspection of ECG is one of the methods. Electrocardiography (ECG) is a tool which is used to understand the condition of the heart. ECG records the electrical signals (activity) which are generated over the cardiac cycle via electrodes positioned at various locations on the body surface.ECG of a patient is examined visually in the time domain. But this ECG is full of noise which can be reduced by means of signal processing. Signal processing is an important and evident tool in fields of biomedical engineering. Today the biomedical signal processing stream has advanced to the stage of practical application of signal processing and pattern analysis techniques. ECG signal is a graphical representation of cardiac activity and it is used to investigate various abnormalities which are present in the heart. Typically an ECG signal consists of P wave, QRS complex, T wave and any deviation in these parameters predict and justify the abnormalities present in heart. Electrocardiogram (ECG) signals are usually contaminated by baseline wander (BW). Electrode-skin impedance changes due to perspiration, patient movement, and respiration which contributes to baseline wander. The computer based processing is influenced due to baseline wander.

Reduction of noise such as BW and power interference is a must, so that the ECG signal can be automatically analyzed by a computer and finally interpreted by a cardiologist. The removal of various disturbances is one of the first steps in the processing of the ECG not only before further automatic processing, but also as a first step in visual diagnosis. The purpose of such diagnosis is to make the processing easier and to enable reliable ST segment measurements [1]. Ambulatory ECG recordings which are taken by placing electrodes on the subject's chest are contaminated by several different types of artifacts. ECG artifacts are the disturbances on ECG which is a measurement of cardiac potentials on human body. Normal components of ECG can get distorted due to artifacts. Artifacts are pretty common and adequate knowledge of them is necessary to prevent misinterpretation of patients ECG. Artifacts can be generated due to electrical interference by outside source, electrical noise elsewhere in the body, poor contact and machine malfunction. Positive stress ECG

test indicates that the QRScomplex alternas is increased and the patients might have significant coronary artery disease [2].

II. LITERATURE SURVEY

In[3], Mbachu presents a method of designing LPF, HPF, BSF with Kaiser window where these three filters are serially connected which process the signal within the range (from 0 to 100 Hz), and with order of 200 for every filter and with interference signals attenuation of 13 dB.

In [4], Verma presents a digital Notch filter design using Hamming window to remove the effect of power line interference (PLI) with frequency of 50 Hz,which achieves 13.4dB attenuation. Also, presents an adaptive filter design to remove the effect of PLI and attenuation of 34.2 dB is obtained.

In [5], Madhukar Narsale et al. present a digital Notch filter design with frequency of 50 Hz and with band width of 45 to 55 Hz. They have implemented this filter on FPGA with sampling frequency of 500 Hz, and attenuation of 13 dB

In [6], Sharma and Dalal have presented a FIR filter whose order is 450 and different windows have been applied to remove the effect of power line interference which has achieved the attenuation of 18 dB.

Choy TT, Leung P M. have implemented 50 Hz notch filters for the real time application on the ECG signal. That filter was capable of filtering noise (by 40 dB) with bandwidth of 4Hz and causes the attenuation in the QRS complex [7].

Markovsky used Band-pass, Kalman, and adaptive filters for removal of resuscitation artifacts from human ECG signals. A database of separately recorded human ECG was used f or evaluation of this method. The performance criterion considered is the signal to-noise ratio (SNR) improvement, which is defined as the ratio of the SNRs of the filtered signal and the given ECG signal. The results show that for low SNR of the given signal, a band-pass filter yields the good performance, on the other hand for high SNR, an adaptive filter yields the good performance [8].

Lebedeva SV et al has described and demonstrated the structure and algorithm of a digital suppression filter for circuit noise at 50 Hz. The filter is seen slightly corrupting the electro-cardio-graphic signal [9].

Daqrouq [27] had used discrete wavelet transform (DWT) for ECG signal processing, specifically for reduction of ECG baseline wandering. The discrete wavelet transform has the properties which enable good representation of nonstationary signal such as ECG signal and divide the signal into different bands of frequency.

III. MATERIALS AND METHODS

The purpose of the ECG simulator is to yield the typical ECG waveforms of different leads and as many arrhythmias as possible. The ECG simulator is a Matlab based simulator and is able to produce normal lead II ECG waveform. The use of a simulator has many benefits in the simulation of ECG waveforms. The paramount one is saving of time and another one is removing the complications 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.

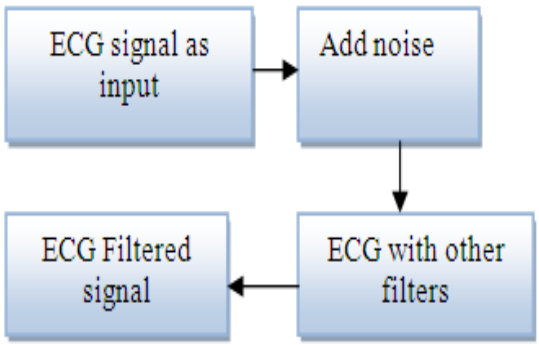

Fig.1 Block diagram

Steps of procedure:

Add Noise to the ECG Signal

To add noise to the ECG signal, the following is to be known,

- The simulated signal
- The time step of the data, i.e. what is the elapsed time between the first data and second data
- The length of your ECG signal, i.e. how many total time does your ECG signal last.

Then to generate the noise signal, use the same time step and generate the signal with the same length and simply add them together. The Savitzky–Golay smoothing filter is a filter that essentially performs a local polynomial regression (of degree k) on a series of values (of at least k+1 points which are treated as being equally spaced in the series) to determine the smoothed value for each point. The main advantage of this approach is that it tends to preserve features of the

distribution such as relative maxima, minima and width, which are usually 'flattened' by other adjacent averaging techniques.

Savitzky-Golay Filter: To smooth a data set is to create an approximating function that attempts to capture important patterns in the data, while leaving out noise or other fine-scale structures/rapid phenomena. In smoothing, the data points of a signal are modified so individual points (presumably because of noise) are reduced, and points that are lower than the adjacent points are increased leading to a smoother signal.

FIR Filter: A finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time. This is in contrast to infinite impulse response (IIR) filters, which may have internal feedback and may continue to respond indefinitely (usually decaying).

Smoothing Filters: Smoothing may be used in two important ways that can aid in data analysis, by being able to extract more information from the data as long as the assumption of smoothing is reasonable, and by being able to provide analyses that are both flexible and robust.

Median Filter: The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image).

Butterworth Filter: The Butterworth filter is a type of signal processing filter designed to have as flat a frequency response as possible in the passband. It is also referred to as a maximally flat magnitude filter.
Notch rejection filter is employed for the removal of humming (50 Hz). As there are two different noises in this case i.e. humming and high frequency noise, both noises after passing through the notch filter, the signal with high frequency noise remain with the original ECG signal in the fifth plot of the figure. Finally the corrupted signal is passed through windowed sinc low pass filter to retrieve the original ECG signal.

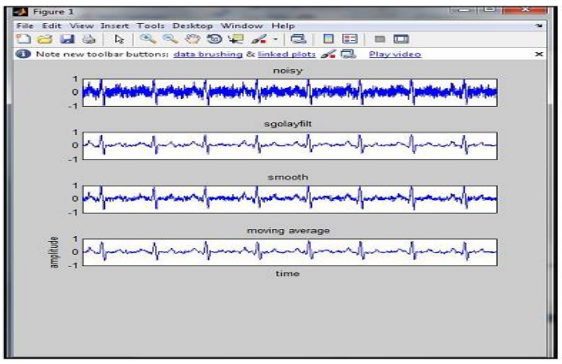

Fig.2 Results of Golay, smoothing and average filters

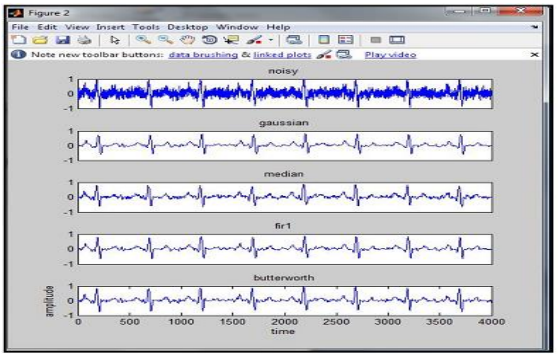

Fig.3 Results of Gaussian, median, FIR and Butterworth filters

The high frequency noise is then filtered out by using windowed sinc low pass filter and the desire output of the ECG signal has then achieved at the final output.

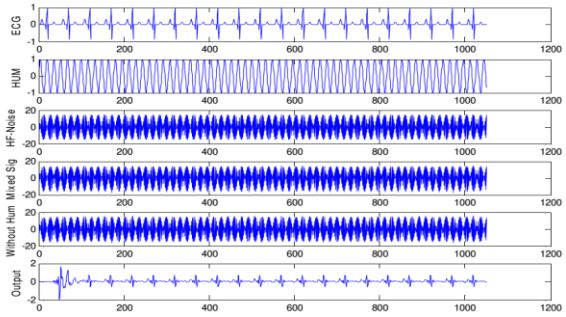

Fig.4 Original ECG Signal with HUM and High Frequency Noise Simulation by Notch Filter

By comparing the graph of input original ECG signal with the output, it is concluded that the overall result of method and technique developed in this thesis is achieved. The goal for the noise cancellation or removal of different noise frequencies has been performed satisfactory. After analyzing the filtering technique for humming and high frequency noise from ECG signal, it is concluded that implementation and analysis has been performed more or less the same and it also shows the method and filtering technique

developed for the removal of harmonics and high frequency noise from ECG signal performed its operation and meet the required results.

IV. CONCLUSION

This work tosses light on the basics of electrocardiogram, artifacts corrupting the ECG signal and ECG enhancement using different algorithms. The work begins with the review of some popular work in the field of ECG signal processing. The physiology of heart, heart beat generation, morphology of electrocardiogram are decoratively discussed. Different types of noises that affect the ECG and their origins are also described. The noise in the ECG signal is filtered using different filters. The results show that golay filter can be effectively used to remove noise in the ECG signal. The different noise levels can be removed using savitzky-golay filter. It has been proposed a solution for the power line interference its respective harmonics and high frequency noise interferences from original ECG signal. The results have been obtained which were required in purpose statement of the paper.

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