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GENERALIZED NOISE REDUCTION IN ECG WAVES USING OPTIMAL SELECTION OF FILTERS

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Abstract

Electrocardiogram (ECG) is a method of measuring the electrical activities of heart. Every portion of ECG is very essential for the diagnosis of different cardiac problems. But the amplitude and duration of ECG signal is usually corrupted by different noises. In this paper we have done a broader study for denoising every types of noise involved with real ECG signal.Two adaptive filters, such as, least-mean-square (LMS) and normalized-least-mean-square (NLMS) are applied to remove the noises. For better clarification simulation results are compared in terms of different performance parameters such as, power spectral density (PSD), spectrogram, frequency spectrum and convergence. SNR, %PRD and MSE performance parameter are also estimated. In the current work we are using Selection of compsite hybrid filter from noise threshold.

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INTRODUCTION

Digital Signal Processing (DSP) is one of the most powerful technologies that are shaping science and engineering in the twenty-first century. Revolutionary changes have already been made in a broad range of fields: communications, medical imaging, radar and sonar, and high fidelity music reproduction, to name just a few. Each of these areas has developed a comprehensive DSP technology, with its own algorithms, mathematics, and specialized techniques. The digital filters are an essential part of DSP. In fact, their extraordinary performance is one of the key reasons that DSP has become so popular. The purpose of the filters is to allow some frequencies to pass unaltered, while completely blocking others. The digital filters are mainly used for two purposes: separation of signals that have been combined, and restoration of signals that have been distorted in some way. Analog (electronic) filters can be used for these tasks, as these are cheap, fast, and have a large dynamic range in both amplitude and frequency; however, digital filters are vastly superior in the level of performance

Components of ECG waveform

ECG wave form consists of waves, intervals and segments.

Waves: P, Q, R, S, T and U

Segments: ST, PT

Intervals: PR, RR, QT

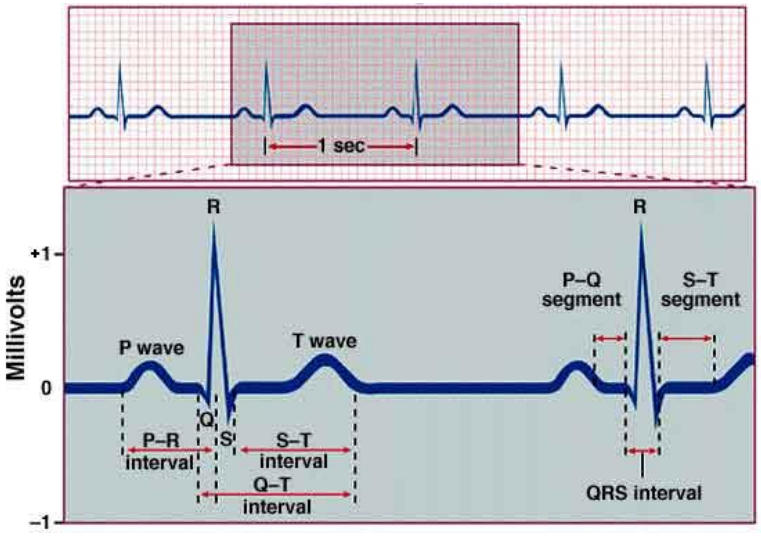


Fig. 1.5 Component of ECG Curve [5]

Conventions on ECG Tracings

The main three features of ECG tracings are:

1. Amplitude
2. Duration
3. Morphology/ Configuration
4. Heart rate
5. Rhythm

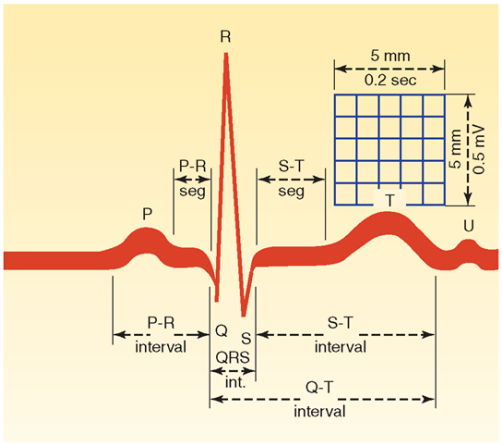


Fig. 1.6 Features of ECG Tracing [5]

1. Wave amplitude represents potential difference ie, voltage. Vertical square scales 0.1 mV and a large square box with five small boxes scales voltage 0.5 mV.

2. Recording paper's speed tells about the duration of the ECG signal. The speed of ecg paper is 25mm/s. The ECG paper is divided into small squares and large squares. Large squares consist of 5 small squares with duration 0.2s and small squares of 1 mm each.

3. Wave morphology depends on the structure that depolarizes the speed at which the depolarizing wave propagates respectively.

4. The normal heart rate at rest ranges from 60-100 b.p.m but the sleeping heart rate is 50 b.p.m. There are several methods to obtain the heart rate from the ECG signal and the most common method is to divide 300 by the number of 5mm between the two R waves.

5. The heart rhythm is normal sinus rhythm. When P wave is positive in I, II, a VF and from V2 to V6, biphasic or positive in III and VI, , biphasic or positive in a VL and negative in a a VR then sinus rhythm is present there.

1.5 ECG Morphology

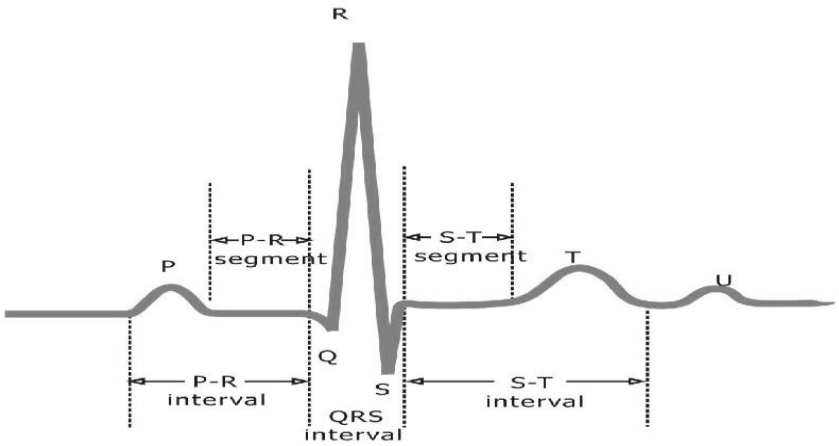


Figure 1.7 ECG Wave Segment [30]

The ECG signal introduced by Einthoven, consists of a linear recording of electrical activity of heart. An atrial depolarization wave (P wave), a ventricular depolarization wave (QRS complex), a ventricular repolarisation wave (T wave) are recorded from the single heart beat. A single heart beat ie, one cycle of the ECG signal is represented with the letters P, Q, R, S and T. The ECG signal can be divided into following parts:

P- Wave: It is produced because of the depolarization of the atria prior to contraction of atria as the depolarization transfers through the atria from the SA node to the AV node and also spread from right to left atrium. The magnitude of P wave is low and 100 msec in duration. Clear P wave shows sinus rhythm are due to the absence of P-wave. When S/N ratio become high it is difficult to analyze P-wave.

QRS- Complex: It is produced when the ventricles depolarize more than their contraction, current is generated. It is the largest amplitude portion of the ECG signal. First atrial repolarisation takes place after that ventricular depolarization takes place. Ventricular depolarization is of greater amplitude than atrial repolarisation therefore not seen on the ECG waveform.QRS complex shows the information regarding conduction problems in ventricles and also show the time for the depolarization of ventricles.

T-Wave: Repolarisation of ventricle results the precedings of ST segment and T- wave. Its duration is more than QRScomplex, large wave may represent ischemia and hyperkalaemia.
It have positive deflection or may have negative deflection. Duration is of 0.20 sec or less.

U-Wave: It results from the repolarisation of papillary muscles. It is rarely seen and origin is not very much clear.

Difficulties in ECG Signal

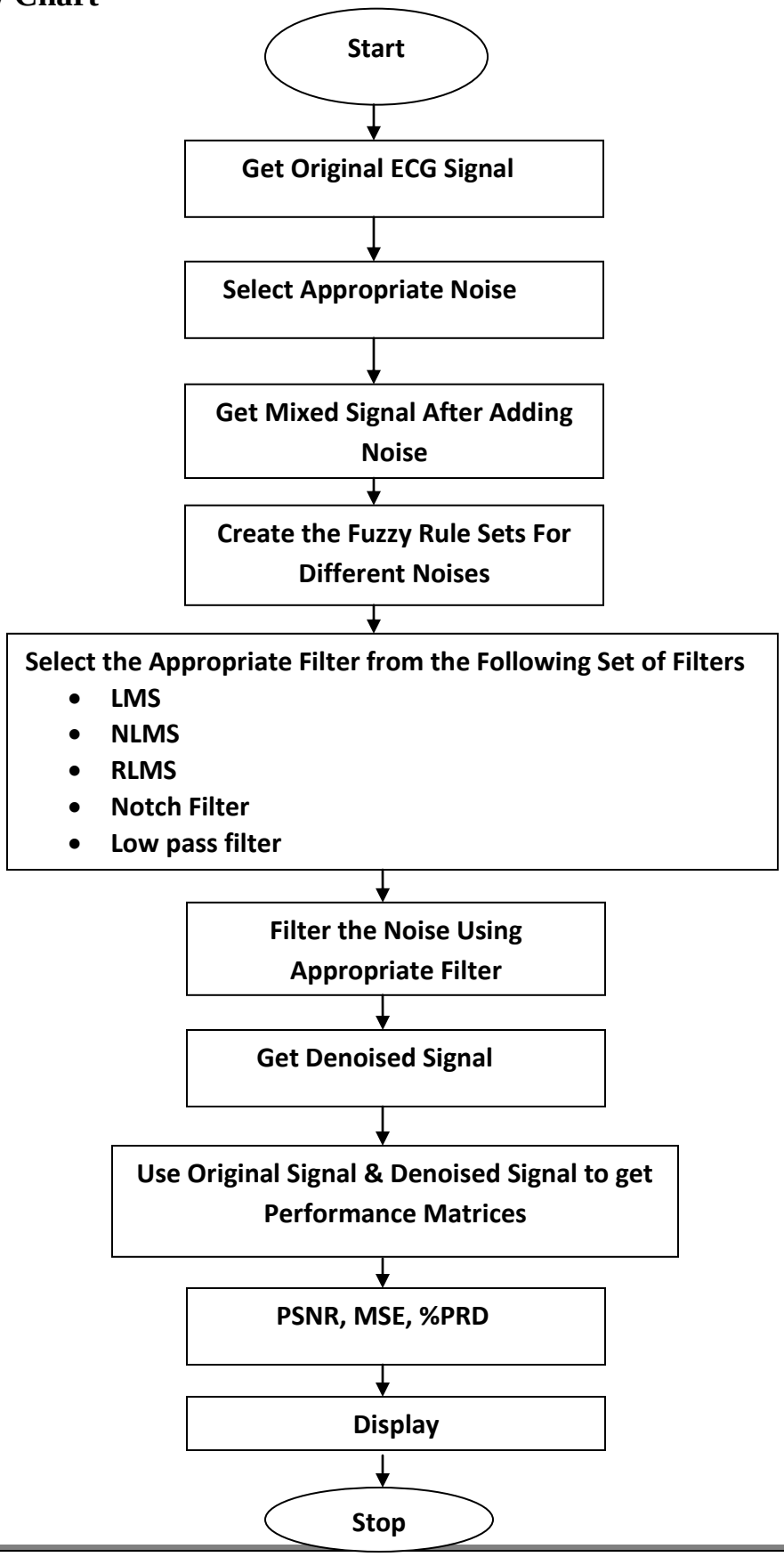
A system may be defined as an integrated unit composed of diverse, interacting structures to perform a desired task. The task may be filtering of noise, detection of range of target in ECG Signals. The function of system is to process a given input sequence to generate an output sequence .Some of the key points that need to be addressed , Single type of filter is not applicable for types of noises . Thus if appropriate noise be removed with appropriate filters then result would have greater information and accuracy. Thus from set of filter we need to estimate which particular filter would be best selection for particular input noise.

Proposed Method

Electrocardiogram (ECG) is a method of measuring the electrical activities of heart. Every portion of ECG is very essential for the diagnosis of different cardiac problems. But the amplitude and duration of ECG signal is usually corrupted by different noises. In this we have done a broader study for denoising every types of noise involved with real ECG signal. For better clarification simulation results are compared in terms of performance parameter such as, power spectral density (PSD). SNR, %PRD, PSNR and MSE performance parameter are also estimated. In the current work we are using predictive Selection of filters using Fuzzy Logic.

Predictive Selection Filter (PSF) is a new approach for ECG Signal denoising. The set of filters are used to improve the quality of a distorted signal. Fuzzy rule set is created for the different types of noises. The prediction result determines each filter which is used to obtain the final processed output. The PSF serves as a framework for combining the outputs of a number of different user selected filters, each best suited for different mixed Signal. This scheme improves the quality of the Input Signal over a variety of Samples content with different characteristics. Developing an effective method of Denoising, in terms of computation efficiency is important for the design of probabilistic framework that lead to an easy implementation. ECG Signal Denoising using PSF Filter with Fuzzy logic is done in the proposed work. Predictive Selection Filter (PSF) provides a systematic method for combining the advantages of multiple filters into a single general framework. We assume that a set of filters has been selected a prior to improve the quality of a distorted signal. Decision is made based upon the rule set.

3.6 Flow Chart



Simulation Results

The ECG signal of 50Hz is generated by MATLAB. The PLI noise of 50Hz, baseline wander of 1Hz, white noise and EMG noise of 300 Hz are also generated by MATLAB. The implementation is done by GUI toolbox under software MATLAB. All the four types of noises are added to the original ECG signal one by one and mixed signal (ECG + noise) is obtained. The decision making tool that is used for the analysis of varying parameters is fuzzy rule based system. It is useful in making decision for the system. In Fuzzy, rule set is added for selection of filters for different noises and decision is made based on the rule set. In the rule set following combinations are used for different noises: combination of LMS and RLS is used for baseline wander noise, notch filter and low pass filter is used for EMG noise, LMS and RLS is used for PLI noise, NLMS and RLS is used for white noise. Different combination of filters are selected from the set of filters ie, LMS, NLMS, RLS, Notch and lowpass filter to retrieve the quality and useful information from the noised ECG signal. Performance comparison of proposed approach with LMS and NLMS filters in terms of PSNR, SNR, %PRD and MSE. The table revels that the proposed technique shows better result than LMS and NLMS for the following four noises. Low MSE and %PRD, high SNR and PSNR shows that the proposed approach is more effective and optimum technique than LMS and NLMS.

NOISES	FILTERS	PSNR	%PRD	MSE	SNR
Power line interference	LMS	60.2991	10.9714	0.060698	-0.80523
	NLMS	60.5008	10.7195	0.057943	-0.60352
	Filters using fuzzy	62.3609	8.653	0.051535	1.243
Baseline wander	LMS	60.3357	10.9252	0.060188	-0.76863
	NLMS	60.6348	10.5553	0.056182	-0.46945
	Filters using fuzzy	64.1267	6.8872	1.8173	1.243
EMG Noise	LMS	60.4498	10.7827	0.058628	-0.65453
	NLMS	60.6276	10.5642	0.056276	-0.47672
	Filters using fuzzy	60.8745	10.2681	0.053166	-0.22984
White Noise	LMS	60.2348	11.0528	0.061602	-0.86945
	NLMS	60.4657	10.7629	0.058413	-0.63858
	Filters using fuzzy	61.9384	9.0851	0.056889	0.81895

Table 4.1 Performance Parameters in terms of PSNR, %PRD, MSE, SNR

Conclusion :

Analysis of ECG signal, both of noisy ECG signal and filtered signal shows that adaptive NLMS, LMS filter and both reduces the white noise, electrode movement noise, baseline wander noise, composite noise and power line interference properly. But the different parameters SNR, %PRD, MSE and also visual parameters PSD, frequency spectrum and convergence reveals that adaptive NLMS filter is more appreciable for removing various types of noises from ECG signal.

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