Denoising Of ECG Signal Using Mixed Windowing Technique

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Abstract:

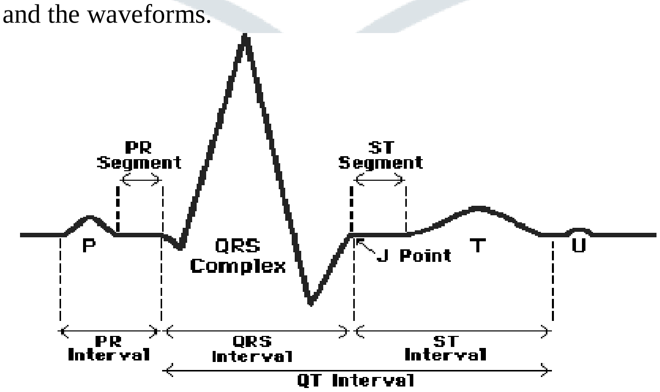
Electrocardiogram (ECG) is used for detection and diagnosis of various heart related diseases. ECG signal plays a vital role in monitoring the heart functions of the patients. There are several noises present in the ECG signal like muscle noise, PLI (Power line interference), contact noise etc. Most commonly the digital FIR filters are designed to reduce the noise. This paper deals with mixed windowing technique for designing a Digital FIR low pass filter. Mixed windowing technique is nothing but the combination of any two windowing techniques. The performance of the filter outputs based upon the SNR. Finally, the SNR of various mixed windowing techniques are compared with the SNR of individual windowing techniques .The whole work will be done in MATLAB Environment.

IndexTerms:

ECG (Electrocardiogram), SNR (Signal-to-noise ratio), Digital FIR filter, Mixed windowing, MATLAB TOOL.

1. INTRODUCTION:

ECG is representing the signal of the heart in the form of pulses. This project deals with design and development of digital FIR filter. Heart diseases which are one of the major death reasons, among the several serious problems in the century and as per the latest survey, 60% of patients die due to heart related diseases. ECG signal plays a vital role in the monitoring and diagnosis of the health conditions of human heart. The basic ECG signal has the frequency range from 5Hz to 100Hz. The most significant noises that corrupt ECG signals are power line interference and baseline wander. It becomes difficult for specialist to diagnosis the diseases if artifacts are present in the ECG signal. In commonly to design digital FIR filter to reduce the artifacts. In this we are using the digital FIR filter with the help of windowing technique such as Hamming, Kaiser, Hanning, Rectangle and Triangle With the help of these techniques. It reduces the 50Hz power line noise in the ECG signal. The whole work will be done in MATLAB environment. The result obtained for all filters are compared by comparing the waveforms of original and filtered ECG signals. The performance of the filter outputs are based upon the SNR and the waveforms.



BASIC ECG SIGNAL

2. Design of Digital FIR filters:

To acquire accurate ECG signal these noises have to be removed by using different filtering techniques. In signal processing, the function of a filter is to remove the noise which is present in the ECG signal. The windowing methods are most commonly used method for designing FIR filters. There are two kinds of filters:

1. Analog filter.
2. Digital filter.

In general Digital filters are used as they have many advantages including size, cost and speed. Here FIR filter are preferred over IIR filter because:

1. FIR filters are always stable.
2. They can be realized in both recursive and non- recursive structures.
3. Excellent design methods are available for FIR filters.

The efficiency of different windows in case of FIR filter can be analysed by evaluating following signal to noise ratio (SNR).

2.1 Individual Windows:

There are several windowing techniques such as Rectangle window, Triangle window, hamming window, Hanning window, Kaiser Window, Blackman window. They are:

2.1.1. Rectangle window:

$$W(n) = 1, \quad 0 \le n \le M-1$$
$$= 0, \quad \text{otherwise.}$$

2.1.2 Triangle window:

$$W(n) = 1 + ((2*n)/(N-1)), \quad 0 \le n \le M-1$$
$$= 0 \quad , \text{otherwise.}$$

2.1.3. Hamming window:

$$W(n) = 0.54 - 0.46*\cos[2\prod n/M-1], \quad 0 \le n \le M-1$$
$$= 0 \quad , \text{otherwise.}$$

2.1.4. Hanning window:

$$W(n) = 0.5 - 0.5*\cos[2\prod n/M-1], \quad 0 \le n \le M-1$$
$$= 0 \quad , \text{otherwise.}$$

2.1.5. Blackman window:

$$W(n) = 0.42 - 0.5*\cos[2\prod n/M-1] \quad , 0 \le n \le M-1$$
$$= 0 \quad , \text{otherwise.}$$

2.1.6. Kaiser window:

$$W(n) = i(o)(\text{alpha}\sqrt{1-(2*n/N-1)^2})/io(\text{alpha}) \quad , 0 \le n \le M-1$$
$$= 0 \quad , \text{otherwise.}$$

3 Proposed Method:

3.1 Mixed windowing technique:

Mixed windowing technique is defined as mixing of two or more windowing techniques. The mixing of two individual windows may be done by the mathematical operations such as addition, subtraction, multiplication, averaging, ex-or. In this paper, the mixing of individual windows has done by means of addition. The addition operation is used in the mixed windowing technique i.e., the addition of any two existing windowing techniques. The mixed window technique is used for improvisation of the signal response of the filter.

3.2 Mixed Windows:

3.2.1 Triangular + Rectangular Window:

$$W(n) = 1 + [1 + (2*n)/(N-1)] \quad , 0 \le n \le M-1$$
$$= 0 \quad , \text{otherwise.}$$

3.2.2 Rectangular + Hanning Window:

W (n) = 1+[0.5-0.5*cos[2∏n/M-1]], $0 \le n \le M-1$

= 0 , otherwise.

3.2.3 Kaiser + Triangular Window:

W (n) = [i (o) (alpha $\sqrt{1-(2*n/N-1)^2}$)/io (alpha)]+[1+((2*n)/ (N-1))] , $0 \le n \le M-1$

= 0 , otherwise

3.2.4 Hanning + Kaiser Window:

W (n) =[i (o) (alpha $\sqrt{1-(2*n/N-1)^2}$)/io (alpha)]+[0.5-0.5*cos[2∏n/M-1]] , $0 \le n \le M-1$

= 0 , otherwise.

3.2.5 Rectangular + Kaiser Window:

W (n) =1+ [i (o) (alpha $\sqrt{1-(2*n/N-1)^2}$)/io (alpha)] , $0 \le n \le M-1$

= 0 , otherwise.

3.2.6 Kaiser + Hamming Window:

W (n) = [i (o) (alpha $\sqrt{1-(2*n/N-1)^2}$)/io (alpha)] + [0.54-0.46*cos[2∏n/M-1]] , $0 \le n \le M-1$

= 0 , otherwise.

4 Simulation results:

4.1 Individual windows:

Fig 4.1.1 Rectangle window:

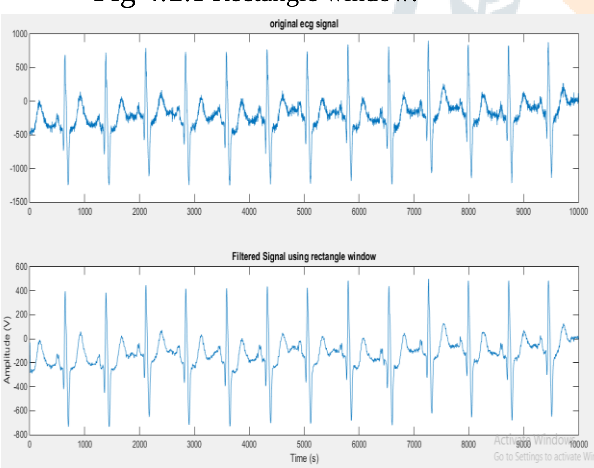


Fig 4.1.2 Triangle window:

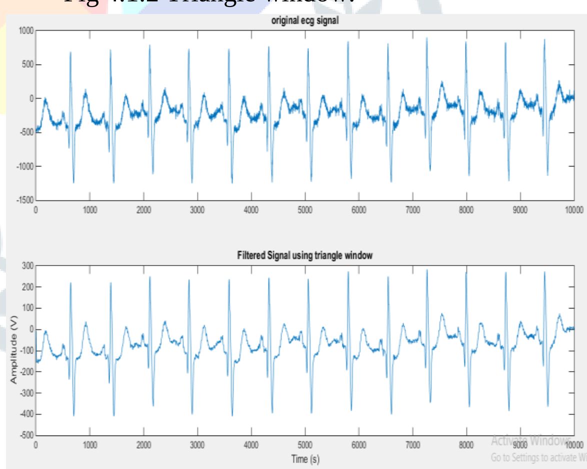


Fig 4.1.3 Hamming window:

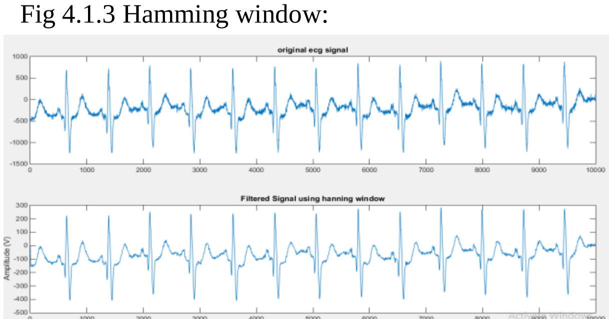


Fig 4.1.4 Hanning window:

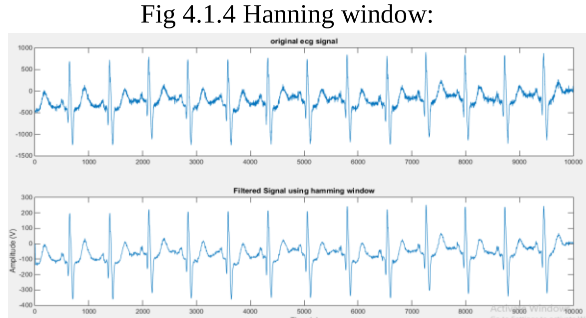
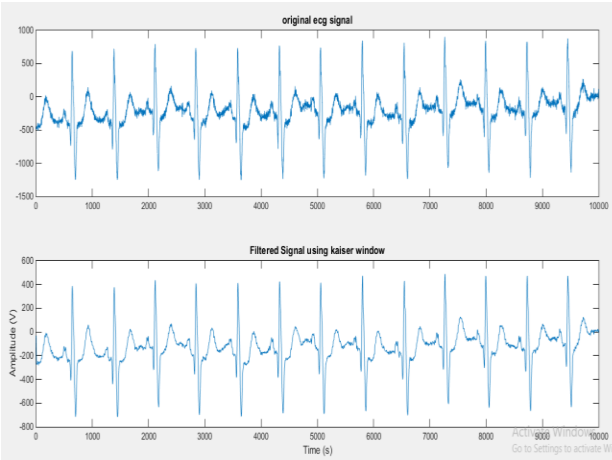
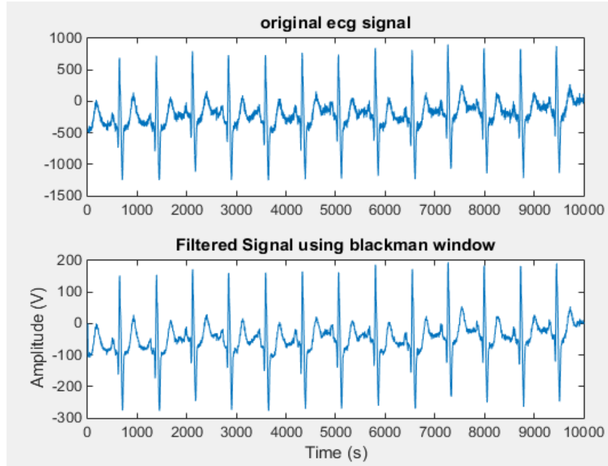


Fig 4.1.5. Kaiser window:

Fig 4.1.6. Blackman window:





4.2 Mixed windowing Technique:

Fig 4.2.1 Triangle +Rectangle window:

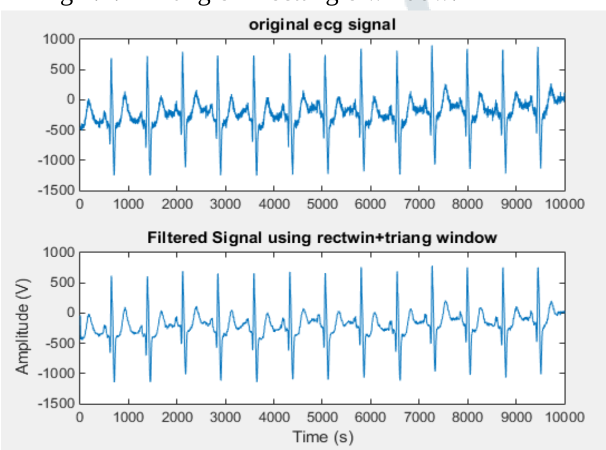


Fig 4.2 Rectangle+ Hanning window:

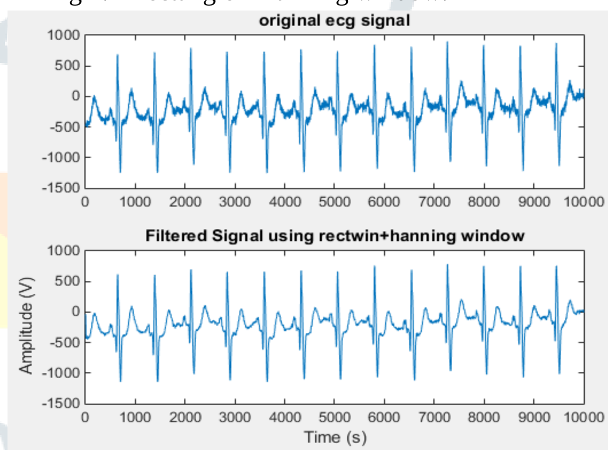


Fig 4.2.3 Triangle+ Kaiser window:

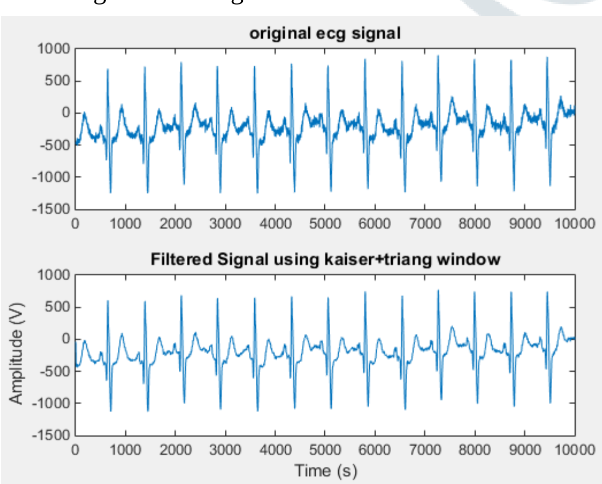


Fig 4.2.4 Hanning +Kaiser Window:

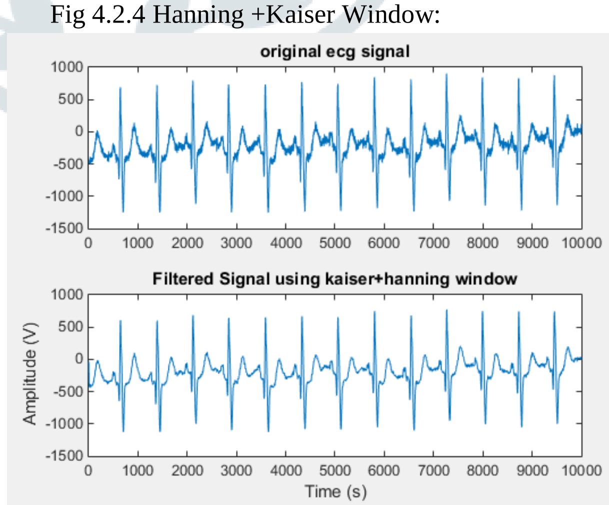
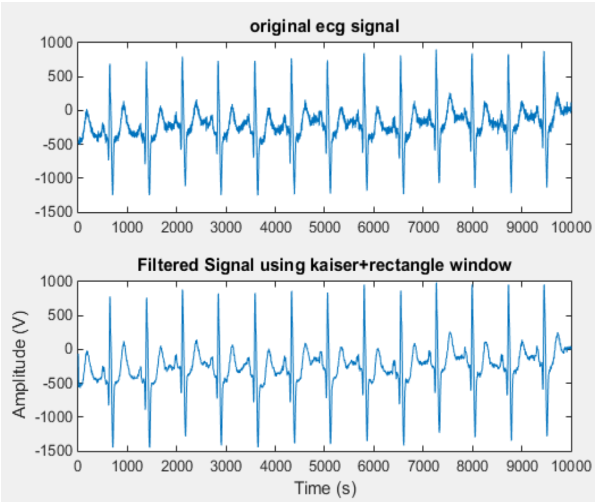
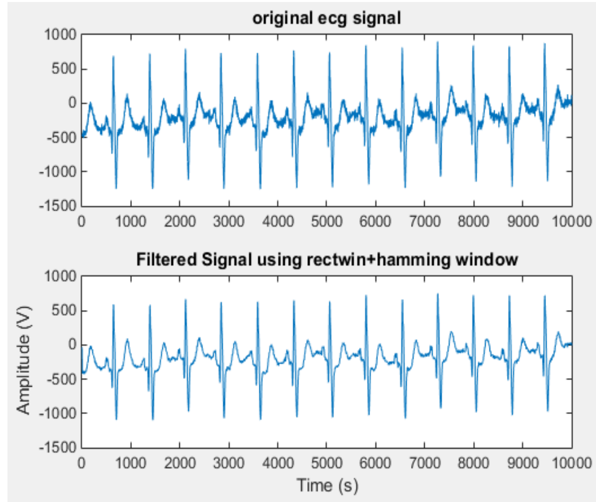


Fig 4.2.5 Kaiser+ Rectangle window:

Fig 4.2.6 Rectangle+ Hamming window:





4.3 SIGNAL TO NOISE RATIO (SNR):

Table 4.3.1Individual Windowing Technique:

S NO	Name of the Windowing technique	SNR
1	Rectangular window	6.2240
2	Triangular window	14.3804
3	Hamming window	17.9953
4	Hanning window	14.3654
5	Blackman window	25.1123
6	kaiser window	5.1240

Table 4.3.2 Mixed Windowing Technique:

SNO	MIXED WINDOWING TECHNIQUE	SNR
1	triangle + rectangle window	29.60
2	rectangle + hanning window	29.57
3	kaiser + triangle window	28.86
4	hanning + kaiser window	28.83
5	kaiser + rectangle window	28.67
6	rectangle + hamming window	27.46

5. Conclusion:

In this paper, ECG signal is filtered by using digital FIR filters with individual windowing techniques and mixed winnowing techniques. The SNR of individual and mixed windowing techniques are tabulated above. From the results, it can be concluded that the mixed windowing technique gives the better de-noised outputs when compared with the individual windowing technique based digital FIR filters.

6. References:

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