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A SURVEY OF NOISE REMOVAL TECHNIQUES FOR ECG SIGNALS

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Abstract: Heart related problems are increasing day by day and Electrocardiogram (ECG) signal are very important in diagnosis of heart related problems. There are various artifacts which get added in these signals and change the original signal, therefore there is a need of removal of these artifacts from the original signal .ECG signals are very low frequency signals of about 0.5Hz-100Hz and digital filters are very efficient for noise removal of such low frequency signals. In this paper we have studied Finite Impulse Response (FIR) filter based on various windows and Infinite Impulse Response (IIR) filters for noise removal of ECG signal and from the results of papers it is seen that kaiser window based FIR filter is better to remove artifacts from ECG signals.

Keywords: ECG, FIR Digital filter, Window techniques, IIR Digital filter.

I. INTRODUCTION

Signal processing is very important and evident tool in fields of biomedical engineering. The biomedical signal processing field has advanced to the stage of practical application of signal processing and pattern analysis techniques for efficient and improved non-invasive diagnosis, online monitoring of critical patients, and rehabilitation. ECG signal is a graphical representation of cardiac activity and it used to measure the various cardiac diseases and abnormalities present in heart. ECG signals are composed of P wave, QRS complex, T wave and any deviation in these parameters indicate abnormalities present in heart. The standard ECG signal is shown in Fig. 1.

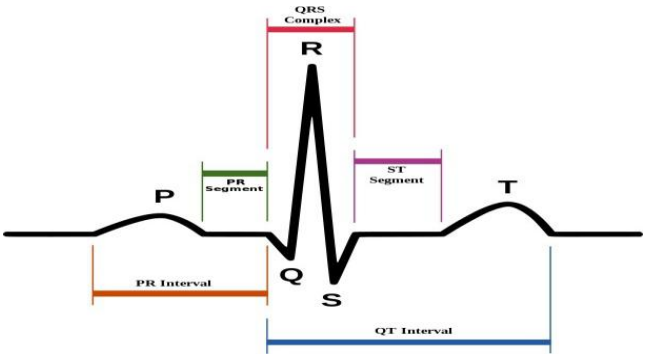

Fig1:- An standard ECG waveform (source: Google images)

The biomedical signal in the present work is the ECG signal and various filtering technique suggested is FIR filter or simply IIR filter. The frequency of ECG signal is between 0.5 Hz-100Hz.This ECG gets corrupted due to various kinds of the artifacts. [1]

1. Power line interference
2. Electrode contact noise.
3. Motion artifacts.
4. Muscle contraction.
5. Base line drift.
6. Instrumentation noise generated by electronic devices.

The ECG signal corrupted due to these noises leads to wrong diagnosis. Therefore, to reduce and remove the noises, digital filters are widely used in biomedical signal processing. Analog filters can also be used to remove these noises, but nonlinear phase shift is introduced by them. Digital filters are more accurate and precise than analog filters. [2]- [3] Digital filters are of two kinds:-

1. Finite Impulse Response (FIR),
2. Infinite Impulse Response (IIR).

II. LITERATURE REVIEW

Mbachu C.B. et.al has used the FIR filter with Kaiser window for removal of noises present on ECG signal.They have designed Kaiser window based low pass filter for

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removing high frequency noise like EEG, high pass filter for removing low frequency noise like baseline wander and notch filter for removing power line frequency noise present in ECG signal with sampling frequency of 1000Hz and they have used filter of the order 100.They have also designed the cascade of all these filters [4]. K.D.chinchkhede et.al have developed FIR filter for ECG noise removal using various windows like Kaiser Window, Blackman Window, Blackman Harris Window, and Gaussian Window and compared their performance based on their output SNR and correlation [5].

Mahesh S Chavan et.al has worked on interference reduction of ECG signal by using fir filter with rectangular window. They have designed rectangular window using low pass filter, high pass filter, notch filter and cascade of the three. They have also compared the baseline wander reduction result and power line interference result of Rectangular window, Hamming window, Hanning window and Kaiser Window [6].Elliptical digital filter for noise reduction of ECG signal were developed [7].

J. A. VAN ALSTE et.al has developed the FIR filter for removal of baseline wander and power line interference due to the linear phase characteristics of FIR filter. They have also reduced the no. of computations involved in digital filters using desired filter spectrum [8]. Neeraj kumar et.al have introduced the Butterworth IIR filter and FIR type –I filter for removal of noise present in ECG signal [1].In "Reduction of Power Line Interference in ECG Signal Using FIR Filter" equiripple FIR filter has been designed for removal of 50/60Hz power line interference present in ECG signals [9].In "Improved SNR of ECG signal with new window- FIR digital filters" a new window is introduced and compared with other windows of FIR digital filter. In this paper high pass filter, low pass filter and band reject filter is used. [10]

III. METHODOLOGY

FIR FILTER: - FIR filters have the impulse response of finite duration and can be implemented without feedback. Window techniques used in FIR filter are:-

A. *Rectangular window :-* the weighting function of rectangular window is given by

$$\omega_R(N) = \begin{cases} 1, for\ |N| \le \frac{M-1}{2} \\ 0, otherwise \end{cases} \quad (1)$$

B. *Kaiser window:-*To achieve the proper stop band attenuation kaiser window with is designed maximum stop band width and minimum stop band attenuation an FIR filter with side lobe attenuation of β dB, Kaiser window parameter α that affects the side lobe attenuation of the Fourier transform of the window is given by

$$\alpha = \begin{cases} 0 & ;\beta \le 21 \\ 0.5842(\beta-21)^{0.4} + 0.07886(\beta-21); & 21 < \beta \le 50 \\ 0.1102(\beta-8.7) & ;\beta > 50 \end{cases} \quad (2)$$

Where $\beta = -20\log_{10}\delta_s$; (3)

C. *Hamming window:-*The hamming window function can be expressed as

$$\omega(n) = \begin{cases} 0.54 - 0.46\cos\frac{2\pi n}{N-1}, 0 \le n < N-1 \\ 0 \quad ,otherwise \end{cases} \quad (4)$$

D. *Hanning window :-* The hamming window function will be expressed by equation

$$\omega(n) = \begin{cases} 0.54 - 0.46\cos\frac{2\pi n}{N-1}, 0 \le n < N-1 \\ 0 \quad ,otherwise \end{cases}$$

(5)

E. *Blackman window:-*The Blackman window function is given by

$$\omega_B(n) = \begin{cases} 0.42 - 0.5\cos\frac{2\pi n}{N-1} + 0.08\cos\frac{4\pi n}{N-1} ; 0 \le n \le N-1 \\ 0, \quad ; otherwise \end{cases}$$

(6)

IIR FILTER:-IIR filters have the infinite impulse response and it can be designed using filters like,

A. *Butterworth filter:-* The magnitude response of Butterworth low pass filter is given as

$$|H(j\Omega)| = \frac{G}{\left[1+\left(\frac{\Omega}{\Omega_c}\right)^{2N}\right]^{1/2}} \quad (7)$$

Where G is the filter gain and Ω_C is 3-dB cut off frequency.

B. *Chebyshev filter:-* The magnitude response is given by

$$|H(j\Omega)| = \frac{G}{\left[1+\varepsilon^2 C_N^2\left(\frac{\Omega}{\Omega_c}\right)\right]^{1/2}} \quad (8)$$

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Where G is the filter gain and Ω_C is 3-dB cut off frequency, ε is a constant and $C_N(x)$ is a Chebyshev polynomial of N^{th} order.

C. Inverse Chebyshev filter:- The magnitude response is given as

$$|H(j\Omega)| = \frac{\varepsilon C_N(\Omega_2/\Omega_C)}{\left[1+\varepsilon^2 C_N^2\left(\frac{\Omega_2}{\Omega}\right)\right]^{1/2}} \quad (9)$$

Ω_C is 3-dB cut off frequency, ε is a constant and $C_N(x)$ is a Chebyshev polynomial of N^{th} order.

IV. RESULTS

From various papers it is shown that the digital FIR filter with Kaiser Window removes the artifacts from ECG with less modification in the waveform. Use of rectangular window gives the more distorted signal hence lead to improper diagnosis. Here the results of various papers are summarized and are shown in table below.

TABLE I
RESULTS OF REDUCTION OF POWER LINE INTERFERENCE USING WINDOWS [6]-[7]

Type of Filter	Filter Order	Signal power before Filtration in dB	Signal power after Filtration in Db	Effect on PQRST Waveform
Rectangular Window	100	-27.18	-29.58	More Distortion
Hanning Window	100	-27.18	-28.77	Less Variation
Hamming Window	100	-27.18	-29.18	Less Variation
Kaiser Window	100	-27.18	-29.59	Less Variation
Butterworth	4	-27	-100	Not modified
Chebyshev I	4	-30.93	-52	Not modified

Mahesh S Chavan have used various FIR filter using various window of the order 100 shown in above table according to which kaiser window should be used because it gives better signal with less variation in waveform[6].

V. CONCLUSION

As the noise present in ECG signal lead to improper diagnosis so the digital filters can be used to remove these noises. The FIR filters have the following advantage over IIR filters.

1. FIR filter are always stable as they have non-recursive structure.
2. They gave the exact linear phase.
3. Efficiently realizable in hardware.
4. The filter response is of finite duration.

Thus noise removal using FIR digital filter is better option in comparison with IIR digital filter.

REFERENCES

[1] Neeraj kumar, Imteyaz Ahmad, Pankaj Rai "*Signal Processing of ECG Using Matlab*" International Journal of Scientific and Research Publications, Volume 2, Issue 10, October 2012 pg no.1-6

[2] Dr.A.K.Wadhwani,Manish Yadav "*Filtration of ECG signal By Using Various Filter*" International Journal of Modern Engineering Research (IJMER) , Vol.1, Issue2, pg no-658-661 ISSN: 2249-6645.

[3] Aung Soe Khaing and Zaw Min Naing "*Quantitative Investigation of Digital Filters in Electrocardiogram with Simulated Noises*" International Journal of Information and Electronics Engineering, Vol. 1, No. 3, November 2011,pg no-210-216.

[4] Mbachu C.B., Onoh G.N., Idigo V.E., Ifeagwu E.N., Nnebe S.U. "*Processing ECG Signal With Kaiser Window- Based FIR Digital Filters*" International Journal of Engineering Science and Technology, Vol. 3 No. 8 August 2011 pg no.6775-6783.

[5] K.D.chinchkhede, Govind Sharan Yadav, S.R.Hirekhan, D.R.Solanke "*On the Implementation of FIR Filter with Various Windows for Enhancement of ECG signal*" International Journal of Engineering Science and Technology Vol. 3 No. 3 March 2011pg no.2031-2040.

[6] Mahesh S Chavan, R A Agrawala, M.D. Uplane. "*Interference Reduction in ECG using Digital FIR Filters based on rectangular window*" Wseas Transactions On Signal Processing Issue 5, Volume 4, May 2008 pg no.340-349

[7] Mahesh S Chavan, R A Agrawala, M.D. Uplane. "*Digital Elliptic Filter Application for noise Reduction in ECG Signa*l" 4th Wseas International Conference on Electronics, Control & Signal Processing Miami Florida USA 17-19 Nov. 2005 (pg 58-63).

[8] J. A. Van Alste, T. S. Schilder "Removal *of Base-Line Wander and Power-Line Interference from the ECG by an Efficient FIR Filter with a Reduced Number of Taps*" IEEE Transactions On Biomedical Engineering, vol. bme-32, no. 12, December 1985 pg no-1052-1060

[9]Ms. Geeta Kadam, Prof.P.C.Bhaskar "R*eduction of Power Line Interference in ECG Signal using FIR Filter*" International Journal of Computational Engineering Research ,ISSN: 2250–3005 ,Mar-Apr 2012 |,Vol. 2 ,Issue No.2, pg no.314-319

[10] D.V.L.N.Sastry, Korada Srinadh Gupta, Velamala Mohana Krushna, Dwarampudi S V Siva Nagendra Reddy *"IMPROVED SNR OF ECG SIGNAL WITH NEW WINDOW- FIR DIGITAL FILTERS"* International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 1, Issue 3, September 2012, pg no.82-85.

[11] Manpreet Kaur , Birmohan Singh , J.S.Ubhi, Seema Rani "*Digital Filteration of ECG Signals for Removal of Baseline Drift*" 2011 International Conference on Telecommunication Technology and Applications Proc .of CSIT vol.5 pg no.105-109.

[12] A text book on digital signal processing by S. Salivahanan, A. Vallavaraj ,C.Gnanapriya.

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