Design and Implementation of Mixed Signal Filter For Continuous Monitoring of ECG Signal

Mr. Vinitkumar V Patel[1], Dr. Mahesh B Dembrani[2]

[1.] Assistant Professor, Department of Electrical Engineering, R C Patel Institute of Technology, Shirpur,
[2]. Assistant Professor, Department of Electronics and Telecommunication Engineering, R C Patel Institute of Technology, Shirpur

Abstract:
Electrocardiogram signal comprises of several mixed signals along with desired signal. Various techniques are used to separate this mixed signal. Signal pre-processing and detection algorithm involves different classification methods such as wavelet based denoising procedure which reduces noise from the ECG signal. Distributed Arithmetic mixed signal filter is proposed in this paper through which various moving arithmetic operations are used to improve the response for real time QRS detection. This complete technique gives accurate detection of QRS wave with high memory efficiency and high speed. Performance analysis is validated by using Cardiac signal database. This analysis is based on accuracy, specificity and sensitivity which show maximum response to obtain the true conditions for ECG signal analysis.

Keywords— DA, Mixed Signal Filter, ECG Signal, QRS detection, DBE.

I. Introduction

Cardiac muscle continuously produces the electrophysiological activity which forms the Electrocardiogram normally known as ECG Signal. This ECG signal gives us the complete activities of heart working conditions. A physician normally uses the ECG signal for the diagnostics of the patient. ECG signal consist of PQRST complex waveform from that QRS complex waveform is most significant for analysis. Instantaneous heart rate (HR) relies on this QRS complex, accuracy of HR depends upon QRS detection [1] [2]. QRS complex is continuously varying which gets affected by noise signal from human organisms. Thus a suitable method is to be realized for exact detection of ECG Signal.

Digital VLSI circuits and DSP processors are normally used for the implementation of the mixed signal filter [3]-[7]. Mixed signal filters consist of analog to digital converter (ADC) and fast sample and hold circuits. Mixed signal filter is an different method to obtain power efficient circuits at a wide range of frequency. In short mixed signal design method provides a nonlinear analog circuit to design all functions required for decoding with higher speed and less power consumption to digital decoders. Digital receivers parallel analog inputs and outputs are not fully compatible with analog recorders.

An adaptive thresholding scheme is applied to perform decision making for detection of QRS complex in nonlinear LPF stage. QRS complex is detected if the peak level of feature signal exceeds the threshold value. As QRS complex wave is detected which updated the value of threshold every time [8] [9].

II. Materials and Methods

The McClellan transformation technique is applied to design 2-D FIR variable digital filters [10]. The variable filter characteristics are same as sub filter due to which they tuned with the same variable parameter. This paper focuses on the sparse FIR filter design algorithms [11]. In this paper the design is based on to reduce nonzero filter coefficients related to weighted least square approximation error imposed on frequency domain analysis. The iterative shrinkage thresholding algorithms (IST) is proposed to use for redundant and sparse representation of signals. A series of constrained sub problems in a simpler form is successively transformed from the original non convex problem in this proposed method. These sub problems can be efficiently and reliably solved in each iterative step by a numerical approach developed, despite of then on convexity. The obtained solutions are essentially optimal to their respective sub problems. The proposed algorithm [11] is computationally efficient since its major part only involves scalar operations. It is necessary to represent the coefficients of a finite impulse response (FIR) digital filter by a finite number of bits. This not only degrades the filter frequency response but also introduces a theoretical limit on the performance of the filter.

III. Proposed Methodology

From various analysis reports on filter design, it is evident that most of the filter coefficients are symmetric in nature. Coefficient sharing is one of the most effective ways of exploiting the symmetric property thereby improving the area and performance of a finite impulse response filter. Hence for our work, to make the architecture efficient the design approach herein involves designing an efficient technique for sharing the filter coefficients that are similar, thereby reducing the number of storage devices count to half when compared to that of its counterpart. The reduction in the number of coefficient storage will also leads to the reduction in all other related components.

Since the design of coefficient sharing technique involves less hardware resource compared to the existing architecture the overhead will be less. To demonstrate the functionality and efficiency of our proposed FIR filter architecture, the filter is configured as a comb, a low-pass, and a band pass filter and compared with that of similar existing works. The proposed methodology is applied for medical application to obtain the accurate detection of the ECG Signal. Performance measures are tested for the analysis of the signal such as to obtain FPR, PPV and NPV.

IV. IMPLEMENTATION & RESULTS

In this paper the Independent Component Analysis (ICA) is used for the separation of the Noise Signal and ECG Signal. The noise signal can be due to motion artifacts or other signal from body tries to override on it. ICA is validated based on Atrial Activity (AA) and Ventricular activity (VA) generated by independent sources, AA and VA presents non-Gaussian distributions and ECG potentials from the cardioelectric sources can be considered as a narrow-band linear propagation process.

The figure 1 shows the normal ECG signal which shows the normal condition. Figure 2 shows the noise signal.ICA separates the noise signal and correctly estimates the noise and filtered ECG signal as shown in figure 3. The mean square error rate can be also calculated from the signal as shown in figure 4 the result of ICA which clearly gives the information of health by appropriate testing of the signal.

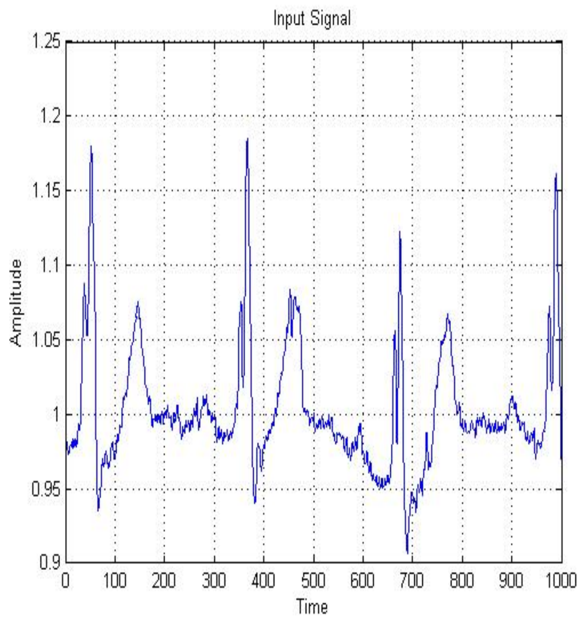

Figure 1 Normal ECG Signal

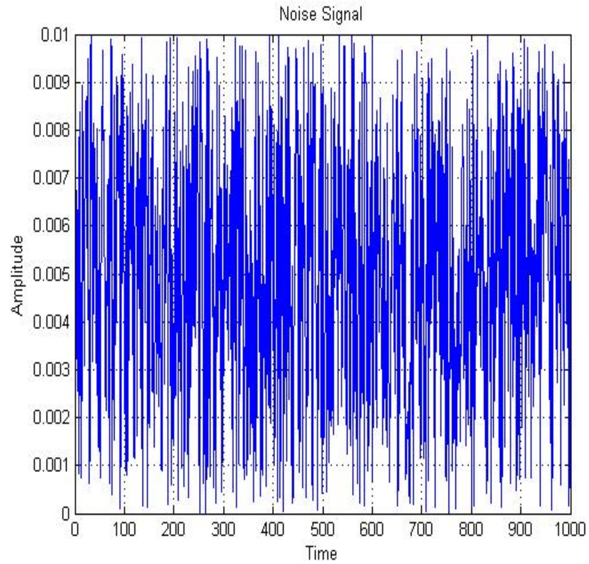

Figure 2 ECG Signal along with Noise Signal

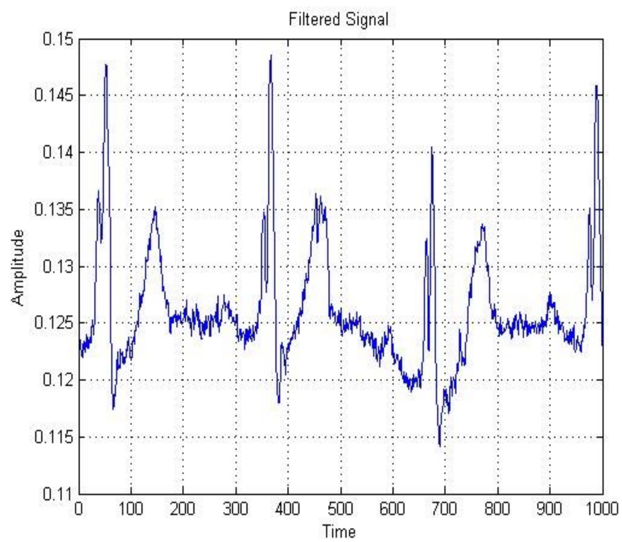

Figure 3 Accurate ECG signal Response using ICA

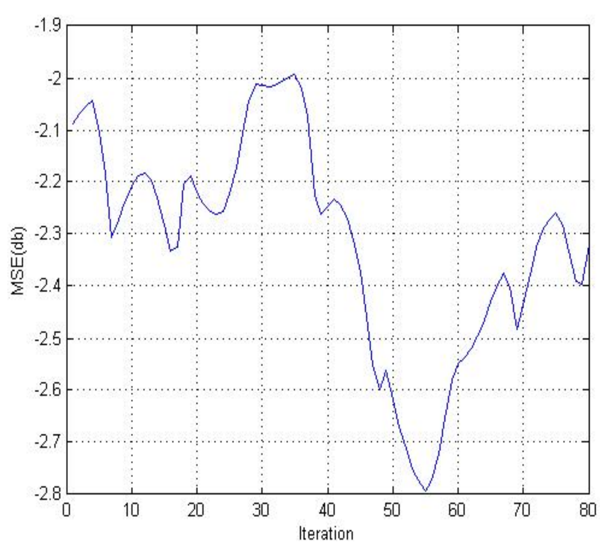

Figure 4 Mean Square Error response in (db)

4.1 Performance Measures

To Evaluate the Performance of the proposed algorithm, several terms are considered as FP (False Positive) which means false heart beat detection and FN (False Negative) which means failed to detect true heart beat rate.

4.1.1 Accuracy

Accuracy is used as a statistical measure of how a classifier and filtering techniques identifies the condition. The accuracy is the proportion of true results both true positives and true negatives among the total number of cases examined.

$$Accuracy = \frac{TP + TN}{TP + FN + TN + FP} \times 100\%$$

4.1.2 Specificity

Specificity is related to the ECG signal condition is normal (no disease). High Specificity shows that the Monitoring System obtains the Normal Condition as Normal.

$$Specificity = \frac{TN}{TN + FP} \times 100\%$$

4.1.3 Sensitivity

Sensitivity is related to the ECG signal condition is abnormal (disease). High Sensitivity shows that the Monitoring System obtains the Abnormal Condition as Abnormal.

$$Sensitivity = \frac{TP}{TP + FN} \times 100\%$$

Figure 5 shows the performance of the proposed method in terms of parameters. This shows the improvement in the performance as compared to different classification and filtering methods *with* proposed method.

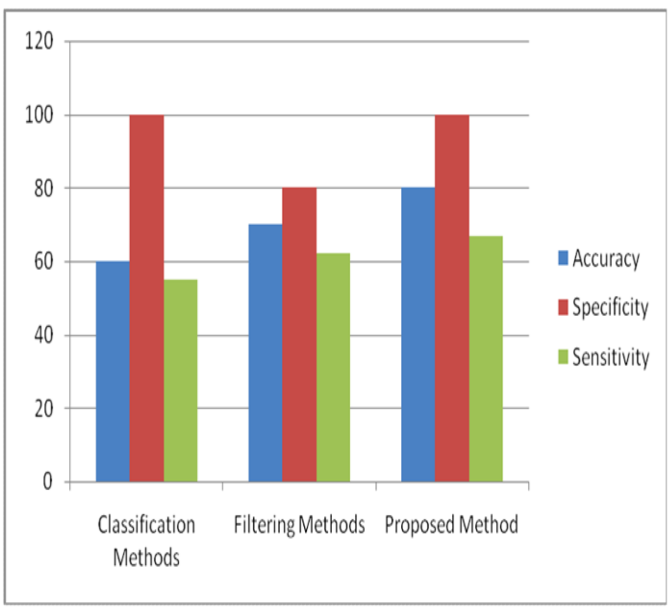

Figure 5 Graphical Representation Comparison of different methods

V. CONCLUSION

In this paper, a mixed signal DA method for real-time QRS detection is introduced. In conjunction with classification methods such as wavelet denoising for signal preprocessing the algorithm can successfully and reliably detect almost all QRS complexes for a set of noise corrupted ECG data drawn from a standard database. Moreover, according to our study it appeared that the novel thresholding strategy proposed for denoising in this study can effectively reduce the level of unstructured noise while the important features of the ECG signal.QRS complex, can be well detected accurately at the same time. In addition, the overall computational structure of the proposed algorithm allows the QRS detection to be performed in real-time with high time- and memory-efficiency. Our results also indicated that there might exist a degree of flexibility for parameter value selection as well as robustness over a wide range of noise contamination in the proposed QRS detection algorithm.

REFERENCES

1.Kohler B. U., Hennig C., Orglmeister R., 2002, The principles of software QRS detection, IEEE Eng. Med. Biol. Mag, pp. 42–57.

2. Chan H. L., Chou W. S., Chen S. W., Fang S. C., Liou C. S., Hwang Y. S.,2005, Continuous and online analysis of heart rate variability, J. Med. Eng. Technol.227–234.
3. Zahabi M., Meghdadi V., Cances J., and Saemi A., 2008, Mixed-signal matched filter for high-rate communication systems, IET Signal Processing, vol. 2, no. 4, p. 354.
4. Milor L., 1998, A tutorial introduction to research on analog and mixed-signal circuit testing, IEEE Transactions on Circuits and Systems II Analog and Digital Signal Processing, vol. 45, no. 10, pp. 1389-1407.
5. Campbell D., Jones E., and Glavin M.,2009, Audio quality assessment techniques A review and recent developments, Signal Processing, vol. 89, no. 8, pp. 1489-1500.
6. Gudmundson M., 1991, Correlation model for shadow fading in mobile radio systems, Electron. Letters, vol. 27, no. 23, p. 2145.
7. Murata N., Ikeda S., and Ziehe A., 2001, An approach to blind source separation based on temporal structure of speech signals, Neurocomputing, vol. 41, no. 1-4, pp. 1-24.
8. Dobbs S. E., Schmitt N. M., and Ozemek H.S., 1984, QRS detection by template matching using real-time correlation on a microcomputer, J. Clin. Eng. 197–212.
9. Xue Q., Hu Y. H., and Tompkins W. J., 1992 Neural-network-based adaptive matched filtering for QRS detection, IEEE Transactions on Biomedical Eng., pp. 317–329.
10. JyShyu Jong, Chang Soo Pei, and Huang Yun Da, 2009, Design of Variable Two Dimensional FIR Digital Filters by McClellan Transformation, IEEE Transactions on Circuits Systems I, vol. 56, no. 3, pp. 574-582.
11. Jiang A. and Kwan H., 2013, WLS Design of Sparse FIR Digital Filters, IEEE Transactions on Circuits Systems I, vol. 60, no. 1, pp. 125-135.