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Mixed Signal Filter Implementation and Performance Analysis based on Accuracy, Sensitivity and Specificity for Monitoring ECG Signal

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Abstract

Objectives: Digital signal processing applications are becoming more prevalent in everyday use. Because of this widespread usage and advances in technology, DSP algorithms themselves are being subjected to more demanding specifications. **Methods/Statistical Analysis**: There is a constant need for designing systems with higher accuracy, sensitivity and specificity. Electrocardiogram signal comprises of several mixed signals along with desired signal. Various techniques are used to separate this mixed signal. In this paper a mixed signal filter and have been proposed and developed, in order to obtain high performance through simulation. **Findings:** 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. **Application/ Improvements:** 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.

Keywords: DBE. Distributed Arithmetic, ECG Signal, Mixed Signal Filter, QRS detection

1. 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 ECG Signal for diagnostics of 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[3–7].

Digital VLSI circuits and DSP processors are normally used for the implementation of the mixed signal filter[8–12]. Mixed signal filters consist of Analog to Digital Converter (ADC) and fast sample and hold circuits. Mixed signal filter is a 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 receiver's parallel analog inputs and outputs are not totally well-suited with analog recorders.

An adaptive thresholding scheme is applied to execute 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[13,14].

2. Materials and Methods

The McClellan transformation technique is applied to design 2-D FIR variable digital filters[15]. The variable fil-

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ter 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[16]. 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[17,18]. 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 every step by step numerical method developed, despite of then on convexity. The obtained solution is essentially finest to their respective sub problems. Proposed algorithm[11] is computationally efficient since its key part only engage scalar operations. In FIR digital filter coefficients are represented by finite number of bits. This finite number of bits limits the overall performance of filter.

3. 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 lead 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 reveal the functionality and efficiency of 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.

4. Implementation and Results

In this paper, Independent Component Analysis (ICA) is used for 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 Ventricular Activity (VA) and Atrial Activity (AA) formed by independent sources, VA and AA represents ECG potentials with non-Gaussian distributions from the cardioelectric sources which can be considered as a narrow-band linear propagation process.

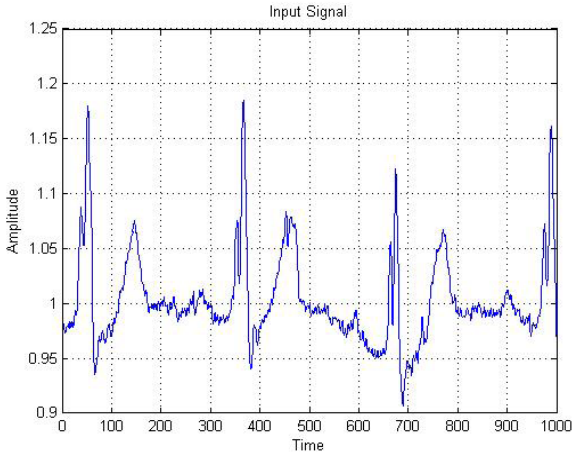

Figure 1. Normal ECG Signal.

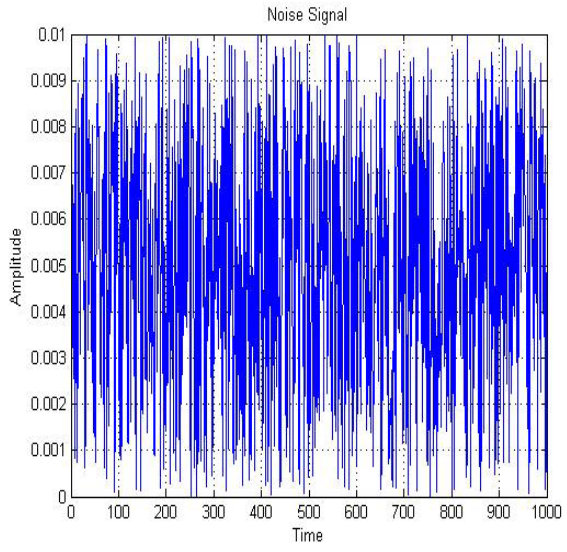

Figure 2. ECG Signal along with Noise Signal.

The Figure 1 shows 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 is shown in Figure 3. 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.

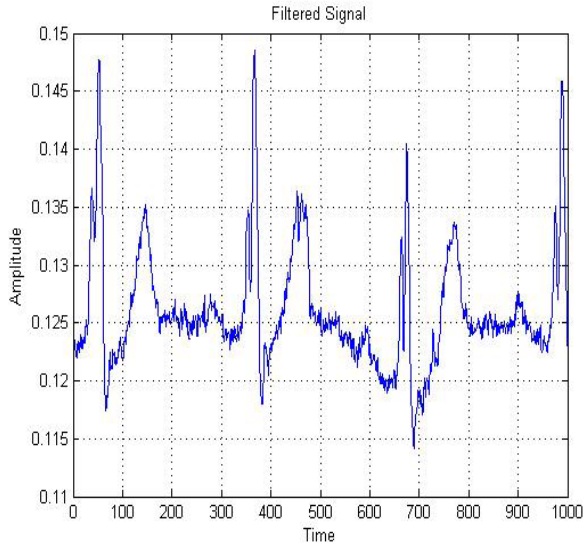

Figure 3. Accurate ECG Signal response using ICA.

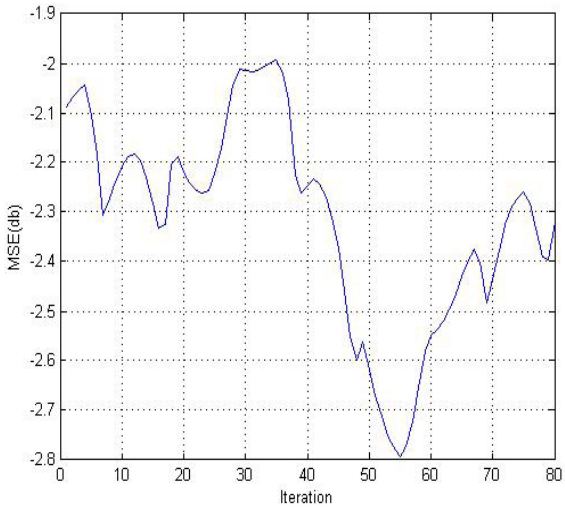

Figure 4. Mean Square Error response in (db).

4.1 Performance Measures

To assess the performance of proposed algorithm, numerous 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

It is exploited as a statistical measure of how a filtering technique identifies the condition. Accuracy is the percentage 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 performance of proposed method in terms of parameters. This shows improvement in the performance as compared to different classification and filtering methods with proposed method.

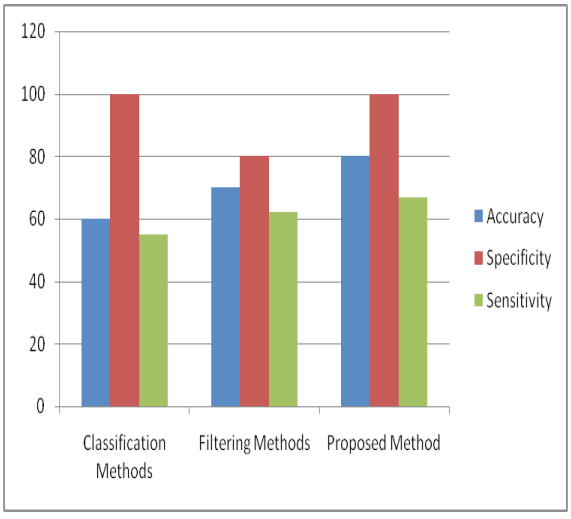

Figure 5. Graphical representation comparison of different methods.

5. Conclusion

In this paper, a mixed signal DA method is implemented for accurate detection of real-time QRS complex. In proposed DA based mixed signal filter various moving arithmetic operations are used to improve the response for real time QRS detection. There is a constant need for designing systems with higher accuracy, sensitivity and specificity. Electrocardiogram signal comprises of several mixed signals along with desired signal. Various techniques are used to separate this mixed signal. Here a mixed signal filter and have been designed and developed, in order to obtain high performance. It gives accurate detection of QRS wave with high memory efficiency and speed.

6. References

1. Kohler BU, Hennig C, Orglmeister R. The principles of software QRS detection. IEEE Eng Med Biol Mag. 2002 Jan-Feb; 21(1):42–57.
2. Chan HL, Chou WS, Chen SW, Fang SC, Liou CS, Hwang YS. Continuous and online analysis of heart rate variability. J Med Eng Technol. 2005 Sep-Oct; 29(5):227–34.
3. Chatterjee G, Somkuwar A. +Gz induced stress monitoring of pilots with synthesized ECG. Indian Journal of Science and Technology. 2010 Jan; 3(1). DOI: 10.17485/ijst/2010/v3i1/29650.
4. Roy R, Venkatasubramanian K. EKG/ECG based driver alert system for long haul drive. Indian Journal of Science and Technology. 2015 Aug; 8(18). DOI:10.17485/ijst/2015/v8i19/77014.
5. Hassan Z, Gilani SO, Jamil M. Improvement in ECG based biometric systems using Wavelet Packet Decomposition (WPD) algorithm. Indian Journal of Science and Technology. 2016 Aug; 9(30). DOI: 10.17485/ijst/2016/v9i30/97958.
6. Hassan Z, Gilani SO, Mohsin Jamil M. Review of fiducial and non-fiducial techniques of feature extraction in ECG based biometric systems. Indian Journal of Science and Technology. 2016 Jun; 9(21). DOI:10.17485/ijst/2016/v9i21/94841.
7. Tirumala Rao P, Koteswarao Rao S, Manikanta G, Ravi Kumar S. Distinguishing normal and abnormal ECG Signal. Indian Journal of Science and Technology. 2016 Mar; 9(10). DOI: 10.17485/ijst/2016/v9i10/85449.
8. Zahabi M, Meghdadi V, Cances J, Saemi A. Mixed-signal matched filter for high-rate communication systems. IET Signal Processing. 2008; 2(4):354–60.
9. Milor L. A tutorial introduction to research on analog and mixed-signal circuit testing. IEEE Transactions on Circuits and Systems II Analog and Digital Signal Processing. 1998; 45(10):1389–407.
10. Campbell D, Jones E, Glavin M. Audio quality assessment techniques - A review and recent developments. Signal Processing. 2009; 89(8):1489–500.
11. Gudmundson M. Correlation model for shadow fading in mobile radio systems. Electron Letters. 1991; 27(23):2145–6.
12. Murata N, Ikeda S, Ziehe A. An approach to blind source separation based on temporal structure of speech signals. Neurocomputing. 2001; 41(1-4):1–24.
13. Dobbs SE, Schmitt NM, Ozemek HS. QRS detection by template matching using real-time correlation on a microcomputer. J Clin Eng. 1984 Jul-Sep; 9(3):197–212.
14. Xue Q, Hu YH, Tompkins WJ. Neural-network-based adaptive matched filtering for QRS detection. IEEE Transactions on Biomedical Eng. 1992 Apr; 39(4):317–29.
15. Jong J, Pei CS, Da HY. Design of variable two dimensional FIR digital filters by McClellan Transformation. IEEE Transactions on Circuits Systems. 2009; 56(3):574–82.
16. Jiang A, Kwan H. WLS design of sparse FIR Digital Filters. IEEE Transactions on Circuits Systems I. 2013; 60(1):125–35.
17. Yazhini M, Ramesh R. FIR filter implementation using modified distributed arithmetic architecture. Indian Journal of Science and Technology. 2013 May; 6(5). DOI: 10.17485/ijst/2013/v6i5/33250.
18. Ramu SS, Umadevi S. Realization of low power FIR digital filter using modified DA-based architecture. Indian Journal of Science and Technology. 2015 Aug; 8(18). DOI: 10.17485/ijst/2015/v8i19/77161.