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Design of ECG Signal Analysis Module for Arrhythmia Detection and Its Implementation on FPGA

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Abstract: Electrocardiogram is an important tool in diagnosing the condition of the heart. Extracting the information from the Electrocardiogram is an important task in determining the variations of the electrical activity of the heart. ECG feature extraction plays a major significant role in diagnosing the most of the cardiac diseases. One among the major cardiac diseases is arrhythmia which is abrupt and abnormal heart beat. In case of arrhythmia heart doesn't pump sufficient blood required for the human body and sudden cardiac death may happen and this can even damage vital organs such as brain, heart, etc. of the body. So it is very much needed to determine conditions of arrhythmia and should take necessary measure before the patient reaches some serious condition. Hence in order to find out arrhythmia ECG signal should be analyzed. Main focus in analyzing the ECG signal involves in finding QRS complex and identifying time and frequency variations. By comparing these with variations in the normal ECG waveform it is possible to conclusion whether the patient is suffering from arrhythmia or not. Results have been verified using a combination of Xilinx and Modelsim softwares.

Keywords: Arrythmia, ECG, Heart, QRS Complex

I. INTRODUCTION

Electrocardiogram (ECG) is a nearly periodic signal that reflects the activity of the heart. A lot of information on the normal and pathological physiology of heart can be obtained from ECG. ECG plays a major role in the field of cardiology. ECG is a graphical representation of electrical activity of the atrial and ventricles, which are responsible for repolarization and depolarization. It contains important clinical information of heart.

It is usually measured by placing an array of 12 different electrodes on the body surface of a patient; these electrodes are known as ECG leads. ECG signal has a time varying morphological characteristics named as P, T waves and QRS complex. These waves will be of different amplitudes. Among these QRS complex wave has highest amplitude and specific shape and is the mid to high frequency wave.

P and Q are the low frequency waves. According to this paper even small abnormality in these waves represents the diseases of the conduction system or diseases of the heart. Each of these waves has important relationship with the repolarization and depolarization of the heart.

P-wave represents the depolarization of the atria, QRS complex represents the ventricular repolarization and T-wave is for ventricular repolarization. Extracting the information in the P-QRS-T waves is called feature extraction and it involves in determining the amplitude and intervals in the ECG signals. Variations in length and width of the QRS complex appear for short period of time and continue for indefinite periods of time. A lot of work has been done in the field of ECG signal analysis using various approaches and methods. The development of accurate and quick methods for automatic ECG feature extraction is of major importance.

Therefore it is necessary that the feature extraction is to find as few properties as possible within the ECG signal that would allow successful abnormality detection and efficient prognosis. The basic principle of all methods involves transformation of ECG signal using different transformation techniques including Fourier transform, Hilbert transform , wavelet transform etc.

Physiological signals like ECG are considered to be quasi periodic in nature. They are of finite duration and non-stationary. Hence, a technique like Fourier transforms is inefficient for ECG.

On the other hand wavelet is a very recent addition in this field of research, provides a powerful tool for extracting information from such signals.

There has been use of both Continuous wavelet transform and as well as discrete wavelet transform. An ECG waveform is shown in figure 1.

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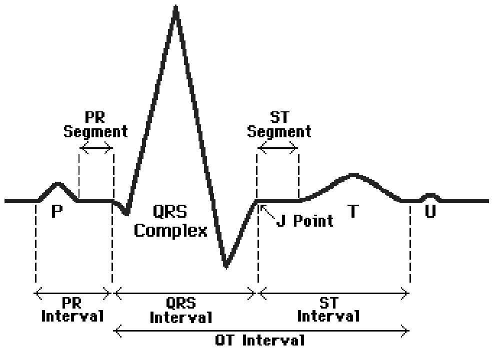

Fig. 1: Normal ECG waveform.

II. LITERATURE SURVEY

P.M. Dudhat, N.P. Joshi , D.S. Pipalia [1], proposed a portable ECG system ,in this paper feature extraction is done by performing several operations on the data like filtering ,differentiation, squaring and time averaging of the signal using ARM cortex A8 processor and a DSP processor which is a OMAP 3530 application based processor which is used for signal conditioning on ECG data and adopted QRS detection algorithm based on matched filter to remove noises in the ECG data. After processing, The data has been sent through wireless communication network by means of a USB dongle, they've sent the ECG data to a remote health care centre and these signals were analysed by physicians so that doctor can login into portable ECG device remotely and read and analyse it to reach conclusion that whether the patient is suffering from arrhythmia or not.

A.K.M Fazul Haque [2], devloped FFT and wavelet method for the extraction of small variations of the signal and shown that proposed wavelet method is superior to the conventional FFT in finding the small abnormalities in ECG signal and employed a 1-D discrete wavelet transform for decomposition process and feature extraction is done using FFT and wavelet method to show that proposed method is superior in finding small abnormalities in ECG signal.

Designing of feed forward neural network with the effect of artificial neural network parameter for feature extraction of ECG signal by employing wavelet decomposition was proposed by Dr. A.k.wadhwari and priyanka agarwal [3] .They employed Daubechies wavelet to decompose the ECG signal in to its higher and lower frequency components and then statistical feature of all components are given as input to neural network. A multilayer feed forward neural network employing a back propagation algorithm was used for learning and training the artificial neural network. and R peak are identified by writing a suitable MATLAB code. Back propogation algorithm is selected as learning algorithm for training and learning of artificial neural network.

Priyanka Mundhe, Harsha Bodhey, Prof. Anuja Diggikar [4], proposed an algorithm for QRS complex detection. In their proposed algorithm the QRS complex is detected by background wondering and noise reduction which is done with the help of mathematical morphology. In this technique the combined opening and closing operators for baseline correction of ECG signals are used and good filtering performance is obtained. In this paper FPGA based morphology algorithm for both resting and wearable exercise ECG QRS detection in BSNs is presented and also shown that the method can also work in case of the bandwidth overlaps between QRS complex and other components.

Dr. R.S.D. Wahidabanu and P. Sasikala devloped a robust R peak QRS detection using wavelet transform [5]. Discrete wavelet Transform (DWT) has been used to extract relevant information from the ECG signal in order to perform classification. In their application Daubechies4 wavelet has been selected for extracting the ECG features.. Analysis was performed on the PQRST waveform. In their work ECG signal is decomposed into several sub bands by applying wavelet transform and then each coefficient is modified by applying a threshold function and finally reconstructs the denoised signal .The detection of the QRS complex is based on modulus maxima of the Wavelet Transform. The QRS complex is also used for beat detection and the determination of heart rate through R-R interval estimation.

III. PROPOSED SYSTEM

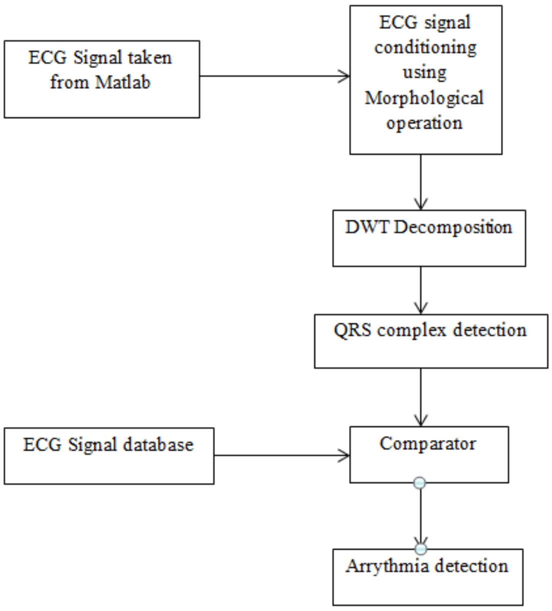

Fig. 2: Proposed Block diagram

Physionet consists of ECG signals of different patients which are downloaded for the analysis and these ECG signals will be in a text header file (.hea) and a binary file (.dat) format. These ECG signals will be first converted into Matlab readable file, such kind of signals are used for processing in this work .The first step here is conditioning of ECG signal which means that noise should be removed

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from the signal which is taken from Matlab then the signal under goes DWT decomposition, here frequency and time analysis will be done then QRS complexion in the signal will be detected and compared with the database to conclude arrhythmia detection.

IV. DWT DECOMPOSITION

DWT is used to decompose the signals into different sub-bands with both time and frequency information. DWT is an appropriate tool for analysis of ECG signal. The basic idea behind decomposition is low pass and high pass filtering with the use of down sampling. The result of decomposition is hierarchically organized decompositions. Lifting scheme is one of the techniques for performing the discrete wavelet transform. Lifting scheme operations can be performed in parallel and it is faster.

Lifting based DWT has three steps

- Split: Input signal is split into even and odd indexed samples. For each pair of given input samples X (n) is split into even X (2n) and odd coefficients X (2n+1).
- Predict: The even samples are multiplied by the predict factor.

- Then the results are added to the odd samples to generate the low pass filtered output.
- Update: The detailed coefficients computed by the predict step are multiplied by the update factors and then results are added to the even samples to get low pass filtered output.

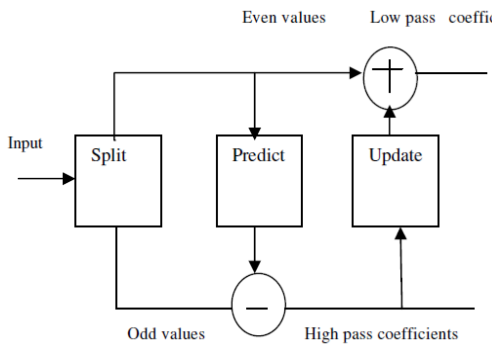

Fig. 3: Lifting based DWT

V. QRS COMPLEX DETECTION

Detection of QRS complex equals to the distinguishing of a group of consecutive positive and negative peaks. Mathematical, morphological technology extracts the effective information based on shapes of the image. Here simple and accurate QRS complex detection algorithm based on morphology is used to detect the QRS complex. Different types of mathematical morphological operations are dilation, erosion, opening and closing. In order to detect the QRS complex a peak extractor is defined only based on basic dilation and erosion morphological operators. The most important element that is necessary for a morphological operation is structuring element. Structural element can be a matrix of any size .The opening and closing operations are a combination of the basic dilation and erosion operations. Mathematical morphology provides an effective way to analyze signals using nonlinear signal processing operators incorporating shape information for extracting signal components that are useful for representation and description.

A morphological operation is actually the interaction of a set or function representing object or shape called structure element. The geometry information of the signal is extracted by using structural element to operate on the signal. The shape of the structural element determines the shape information of the signal that is extracted under such a operation .such operator serves two purposes, i.e. extracting the useful signal and removing the artifacts.

Erosion is used for shrinking or eroding objects in an image. Amount of shrinking required depends on the size of the structural element which in turn depends on the shape of the image or signal to be processed. This operation makes the object smaller by removing the pixel from the edges. Pixels are removed from both the inner and outer boundaries of regions thereby enlarging the holes enclosed by a single region and making gaps between regions larger. They are used for removing extrusions on signal boundaries.

Dilation is an expansion operator. Dilation is having an opposite effect to erosion and adds pixels to inner and outer boundaries of region. It is used for expanding the shape contained in the input signal. And it bridges gaps in the image. During dilation area of foreground pixels grow in size and holes within regions gets smaller. Erosion is performed on the input signal which finds out the maximum value and dilation is performed to detect the minimum value and average is taken which represents the peak value.

VI. CONCLUSION

In this paper, a design of ECG signal analysis module for arrhythmia detection is proposed. The analysis of ECG signal depends upon the accurate detection of various features of ECG signal. Here DWT decomposition technique is used to perform frequency and time analysis. QRS complex is identified and compared with the database to conclude whether the ECG taken for the analysis has arrhythmia or not.

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