ECG Feature Extraction and Signal Processing using Standalone Embedded Systems

ABSTRACT

Computer aided ECG signal analysis is one of the prime areas of research for the scientists for last few decades. The thesis work describes embedded system based ECG feature extraction technique. And finally based on the extracted ECG features, three category of patients were classified. All the developed ECG feature extraction algorithm performances were validated using prerecorded standard ECG databases, which include ptb-db and mit-db ECG databases from Physionet. Algorithms were also tested using Biopac system generated ECG data records in terms of mili volt level ECG sample values, sampled at 1kHz frequency. The sequential progress of the entire work is described by the following steps:

1. Algorithms developed for offline analysis of ECG samples to compute the time-plane and amplitude features which may include different ECG constituent wave durations, heights, polarities and other important wave segment durations including R-R interval, QT interval, PR interval, ST segment slope and direction along with their variances.

2. Two separate algorithms were developed for online QRS complex detection from ECG signal for the purpose of computation of heart rate. The algorithms were implemented on a standalone embedded system based on Atmel 89C51 microcontroller. A PC based ECG simulator was designed which was capable of delivering ECG samples with 8 bit resolution, to the microcontroller board through the serial port (first approach) and parallel port (second approach) of a personal computer (PC).

3. Generally the ECG signal is contaminated with different type of noise or artifacts. So at first it must be filtered for any further analysis. In current implementation only 50 Hz noise was minimized by using a 4th order IIR notch filter. So as to remove other high frequency noises, finally the IIR notch was followed by a 4th order IIR Butterworth low pass filter (final LPF) with 150 Hz cut off frequency.

4. Thereafter an online ECG feature extraction algorithm was developed and was implemented using FPGA based system. A 200 sample FIFO stack was used to hold latest 200 samples all the time through processing. The implementation of the proposed algorithm in FPGA device had a latency of 20 ms (which is 20 sampling interval) for Q, R and S-peak, 50 ms for T and P peak, and 150 ms and 200 ms for offset and onset point detection respectively for P, T waves.

5. An online ECG classifier was developed, which can distinguish anterior MI (Myocardial Infarction), inferior MI and normal subjects from a no of classes of cardiac abnormal patients, based on two parameter values extracted from FPGA implementation, over sequentially processed 12 leads of each ECG records.

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