Chapter 7: Conclusion and Future Scope

The thesis work describes ECG feature extraction and signal processing algorithms using standalone embedded systems. The algorithms were validated using prerecorded ECG data from open source database Physionet.

In the first stage, an algorithm was developed and tested in MATLAB. It detects R- peaks from a single lead ECG and then explores the position of other fiducial points in appropriate window search to reveal all time domain features which are wave durations, wave intervals and their amplitudes.

In the next stage, two R Peak detection algorithms based on slope and amplitude features were developed and implemented on standalone embedded systems employing 8051 microcontroller. The algorithms were tested with digitized ECG data generated from Physionet using a PC-based system. The heart rate was calculated instantaneously.

Noise reduction is an important task in ECG signal processing. In chapter 4, some noise reduction algorithms are described which were implemented in Xilinx FPGA platform.

Finally, fiducial points detection and wave features extraction algorithm was implemented in Xilinx Spartan 3 FPGA board, which receives Physionet data from serial and parallel ports.

An algorithm, based on binary classification of normal and abnormal ECG was developed to detect MI patients.

The chief aim of the thesis work is to develop fast and easy preliminary level assessment of ECG using portable, low-cost and standalone system. The developed algorithm presented in the thesis is of low complexity, memory efficient and implementable in low end processors or entry level FPGA.

Over the last decade, point-of-care (POC) Technology has been one prominent area of biomedical research. The of low power embedded computing in healthcare has significantly contributed towards development of
portable, easy to use gadgets for on-spot-assessment of health parameters. Currently, commercial products are available to estimate blood glucose, pulse rate in hand held gadgets, where patients can monitor their physiological parameters regularly without any assistance. This also saves frequent visit to the physician. Some mobile phone based application are currently in use to monitor daily exercise, daily temperature variation, pulse fluctuations etc. Considering the ever increasing need of patient comfort and flexibility in acquisition, portable healthcare gadgets will be more in demand. The thesis work is aimed to this direction of 'portable healthcare'. The thesis work can be extended in following future direction.

(i) Use of soft computational tools like Artificial Neural Network (ANN), GA etc.. can make the feature extraction algorithms more robust against noise, inter beat variations. However, these will enhance the computational burden as well as memory requirement of FPGA. Currently high density FPGA modules are commercially available which can be used to achieve this.

(ii) Use of simultaneous multi lead ECG analysis, as often used by physicians for real life diagnosis, can provide more accurate results on classification. Simultaneous acquisition can be arranged in by interfacing a multichannel ADC with the FPGA.

(iii) Context aware sensing is an emerging area in personal health monitoring. Here instead of continuous streaming / transmission of medical data, a dedicated patient module is attached to body to process the signals for 'event' (abnormality) detection. An event can be defined as occurrence of an abnormal beta, sudden fall of heart rate etc. When found, the module only transfers the abnormality, its type, time of occurrence with a short strip of concerned lead data at the time of 'event' occurrence to a caregiver (physician, medical professional or relative) through a wireless communication link. FPGA based standalone systems have the potential to be used in such applications.