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Title of the Thesis: Design and Development of Portable Wireless System for Assessment of Human Physiological Parameters

Cost, quality and access are the three major parameters on which the health care systems can be gauged objectively. In view of this, various systems used presently to detect, transmit and analyze human physiological parameters have addressed a wide variety of clinical and technical issues. This includes enhanced power competence, reduced development cost, compact physical structure, convenient sensor arrangement and signal processing, wireless networks etc. which provide adept and simple ways to continuously monitor human physiology. Although enormous research efforts have been made in the fields of human physiological signal monitoring, wireless transmission and signal feature extraction, most of them are truly not affordable and reachable to the masses. There is a further scope for improvement, especially in terms of noise sensitivity, universal connectivity, response time and on-line processing. Advancement in computer based portable data acquisition (DAQ) hardware and software could facilitate development of monitoring instruments which are not only simple but also provide compatibility at a much lesser cost. This thesis focuses on design and development of computer based enhanced system to detect, digitally process and remotely transfer human ECG, EMG and Carotid pulse waveform in real time.

The computer based simple system developed using Piezo-electric transducer allows detection of Carotid Pulse Wave and manifests changes in it under different body postures of human subject. The acquired signal is viewed on a freely downloadable virtual oscilloscope, stored and loaded into MATLAB for digital filtration. It is then transmitted from one PC to another using Windows Hyper-terminal utility and ZigBee wireless network modules. In parallel a Simulink model is created to analyze the effect of digital filtering techniques on real time acquired Carotid pulsation. The system developed is capable of direct interface through the sound port of the PC and does not require proprietary DAQ units and ADC units.

Further, an amplifier arrangement is developed using TL084C instrumentation amplifier and Ag-AgCl sensor to acquire single channel EMG signal under different levels of bicep muscle contractions. Front end of the cascaded amplifier developed include DC restoration circuit, active analog filter and right leg drive. Virtual oscilloscope and digital filter algorithm are developed in MATLAB to view real time filtered EMG signal. A commercially available wireless FM microphone system is used for real time transmission of EMG signal. A dual channel acquisition hardware and algorithm in MATLAB is further developed to simultaneously acquire time coherent EMG and Carotid pulsation so as to analyze the effect of rectus abdominal pressure change in Carotid wave.

Various 50 Hz notch filter designs are verified in P-Spice to evaluate their performance and the developed hardware of the optimized circuit is used along with the tested amplifier system to obtain improved ECG signal. The acquired ECG is transmitted in real time wireless mode using FM transmission module. Further a starter kit from Microchip, dsPIC 33F Digital Signal Controller (DSC), which has a wide application in audio processing, is explored for automated analysis of ECG signal. Algorithm additionally developed in MATLAB for on-line feature extraction enables QRS peak detection, RR interval, Heart rate and power spectral density (PSD) calculation in digitally filtered ECG. The dual channel arrangement is also utilized to acquire time coherent ECG signal and Carotid pulse wave to calculate time domain Heart Rate Variability (HRV) parameters. The statistical time domain HRV parameters successfully evaluated using this arrangement are the mean Heart rate, Mean RR interval, RMSSD, SDNN and SDindex. The algorithm is finally converted into an independent executable stand alone application program. The dual channel arrangement developed correlates time domain HRV parameters derived from ECG and Carotid data. Negligible difference was found in the HRV values derived from both the signals and hence use of Carotid pulse wave for HRV analysis can be explored in critical situations. This thesis thus marks an attempt to provide a relevantly cost effective and universally compatible solution to human physiology real time monitoring, online digital processing and wireless transmission that is more realizable and would directly benefit larger population.

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