CHAPTER 7

SUMMARY AND CONCLUSION

Although there are generally accepted standards for the calculation of HRV metrics and some agreement concerning the clinical application of these metrics the field of HRV analysis contains many contradictory studies and there exists no clear consensus on the clinical value of HRV metrics. This thesis has endeavoured to develop HRV analysis within a principled framework, based on the development of appropriate signal processing techniques and pilot studies in two fields of potential application.

A survey in Chapter 2 identified that ECG signal processing techniques play a vital role for analyzing HRV in diagnosing various diseases and conditions associated with the heart. HRV analysis is also useful for assessing the activities of autonomic nervous system.

Chapter 3 describes the ECG recording of 12 healthy male subjects in the age in between 18 to 25 years have voluntarily participated in the study. Two groups of subjects are selected according to their habits. One group belongs to smoker category and other group from nonsmoker category. Before starting the experiment, all the subjects requested to fill up their written concern and list of questionnaires were asked to identify their initial health and mental condition. The basic introduction about this experiment, such as duration, type of stimuli, purpose of experimentation, and project objectives were clearly explained. The ECG signals also collected from the subject during the entire experiment. The sampling frequency of ECG was set into 5 kHz as per the ECG clinical guide suggestion. Three ring electrodes were placed on the subject based on basis of Einthoven triangle configuration.
The analysis of heart rate variability using windowing techniques and wavelet transform has been enlightened in Chapter 4. The frequency response analysis of ECG signal is performed using triangular, Hamming and Hanning window functions. Spectral decomposition of the Heart Rate Variability was obtained, in order to assess the characteristic fluctuations in the heart rate and their spectral parameters under different conditions. HRV analysis is useful for assessing the activities of autonomic nervous system. Initially the time and frequency response analysis of ECG signal is performed using triangular, Hamming and Hanning window functions. The frequency analysis provides useful information about the ECG signal. The frequency response obtained without window does not have more amplitude variations, whereas the window analysis reveals more information about the ECG signal peaks. The preprocessing using windowing technique removes some amount of noise; however the complete noise elimination can be performed using wavelet transform. The signal-to-noise ratio at different stages are calculated and compared for different wavelets.

This chapter has suggested a new approach to stress assessment using heart rate signals by neuro fuzzy model. The most important contribution of this chapter is to establish a direct functional relationship between heart rate variability and mental stress. The wavelet decomposition and reconstruction techniques are used for removing noise and to extract some important time-frequency features. The spectral features are identified with the application of neuro fuzzy training and mental stress assessment is done using fuzzy clustering techniques. The fuzzy evaluation approach, after being applied to mental stress assessment, motivates the start of new interesting research of physical and mental stress separation.

CONCLUSION
ECG signals are non-stationary, pseudo periodic in nature and whose behavior changes with time. The proper processing of ECG signal and its accurate detection is very much essential since it determines the condition of the heart. The analysis of ECG signal requires the information both in time and frequency, for clinical diagnosis. Hence the wavelet transforms becomes handy for analyzing these types of the signals. Wavelet transform is more suitable for analyzing the non stationary, pseudo periodic ECG signal.

The HRV analysis shows the significant changes between non smoker and smoker (stressed) states more evidently. Low frequency (0.04 to 0.15 Hz) of ECG signal considered to identify the effect of stress instead of usual frequency domain analysis of HRV (0.15 to 0.5 Hz). In order to extract the stress related features the HRV signals are analyzed to verify the changes between stress and relaxed state, the time domain analysis are done using optimum features set. The result shows the significant variation between stress and relaxed state. The RR interval is not uniform on the entire duration of all the 12 subjects and it frequently oscillated between certain ranges. The mode value of histogram is helpful to identify reduction of RR interval variation between relaxed and stress states. This also evidently proves that heart rate significantly increased during the stress. The subject to subject variation also analyzed, the heart rate and standard deviation is not uniform even the subjects are selected from the highly identical backgrounds. We have considered the DWT based wavelet denoising have incorporated using different thresholding techniques to remove three major sources of noises from the acquired ECG signals namely, power line interference, baseline wandering, and high frequency noises. Five wavelet functions ("db1(Haar)", "coif5", "Meyer", "Bior1.1", and "Rbior") and five different thresholding methods are used to remove the noise in ECG signals. A set of eight statistical features was extracted from three different frequency bands of ECG signals. Specifically, Very Low Frequency (VLF)(0Hz-0.04 Hz), Low Frequency (LF)
(0.04 Hz – 0.15 Hz) and High Frequency (HF) (0.15 Hz – 0.5 Hz) and a frequency band ratio (LF/HF). The experimental result shows the "Rbior" wavelet is optimal for unknown Signal to Noise Ratio (SNR) in the real time ECG signals. The “db1 (Haar)” wavelet gives the more suppressed “T” wave and “coif5” gives the disturbed ECG pattern. The overall performance of “Rbior” is better than other wavelet based on morphological characteristics. The “Rbior” based wavelet transform produces the excellent ECG signal even though the signal contaminates power line noise, baseline wander, and low and high frequency noises. Chapter four concludes that the “Rbior” wavelet gives the best result for ECG signal denoising. This method is very simple compared to other denoising approach like genetic algorithm. The maximum mean classification rate of 96.51 % and 96.78 % is achieved using coif5 and Rbior on LF/HF ratio on mean feature. The accuracy of the system is mainly due to the subject selection, enormous variation between relax and stress. The advantage of the proposed system classifies the stress level of the subject using subject independent mode.

Chapter 5 has suggested a new approach to stress assessment using heart rate signals by neuro fuzzy model. The most important contribution of this chapter is to establish a direct functional relationship between heart rate variability and mental stress. The wavelet decomposition and reconstruction techniques are used for removing noise and to extract some important time-frequency features. The spectral features are identified with the application of neuro fuzzy training and mental stress assessment is done using fuzzy clustering techniques.

The new FNN has been developed and presented to classify ECG signals by using three different training and testing sets (or feature sets). A comparative assessment of performance of FNN with MLP NN shows that more reliable results are obtained with FNN classification of ECG signal.
MLP NN is still able to generalize with good recognition accuracy. It has been demonstrated that the training time of the FNN was 60% of the time required by the MLP NN. The aim in developing FNN was to achieve more optimum results with relatively few signal features. We hope the performance of the method will be better, if the number of beats is increased for training. These extracted features were mapped into two states such as (smoker) stress and relax (non smoker) by using FCM technique. In the presence of the data uncertainties and modeling errors, the gradient based techniques are not suitable due to their non-robust nature; we believe FCM methods are suitable for non-linear and linear parameter identification. The existing KNN classifier is subject independent, but it provides the maximum accuracy of 96.88%. But the experimental result of the proposed FCM classifier gives a maximum accuracy of 97.44% on classifying stressed (smoker) and relaxed (non smoker) states. This accuracy gives valuable information about the functional aspects of the heart and cardiovascular system.