ABSTRACT

Respiratory system is one of the most important functional systems of the human body. A thorough investigation of respiratory system is essential for the prevention and optimum management of respiratory impairments. Apart from diagnosis, early detection of degradation in performance of respiratory system will also help the physician to initiate therapeutic measures. During the last decade, information technology professionals have become closely involved in many medical ventures and the modern hospital has emerged as the centre of a sophisticated health care system. There has been a trend for research in analysis of physiological signals using innovative methods. Latest developments in the field of computing environments have aided advanced research in this area. This thesis discusses a few investigations performed in analysis of respiratory signals using novel techniques for diagnosis, and modelling of respiratory system under exercise.

Pulmonary function tests (PFTs) provide means for automated clinical procedures and analysis techniques for carrying out an evaluation of the lung function or the respiratory process. Spirometry is the most widely used PFT for diagnosis and management of respiratory system. Lung parameters measured using spirometer are compared with the reference values of the parameters and based on any significant deviation in values, the physician diagnoses the respiratory disease. Estimation of reference values of lung parameters is very complex because of the various potential sources of variability. A novel technique based on artificial neural network (ANN) has been developed for obtaining the reference values of important lung parameters. This study is confined to South Indian population aged between 15 and 25.
Maximum expiratory flow-volume (MEFV) curve conveys vital information about the condition of respiratory system and can be used for assessing the degree of lung function impairment. A novel method of diagnosis of respiratory system based on model parameters extracted from the MEFV curve is presented in this thesis. Genetic algorithm based optimisation technique was implemented to determine the model parameters which best match the MEFV curves of normal subjects and patients having chronic obstructive pulmonary disease (COPD). Usefulness of the model parameters for diagnosis of COPD was examined using artificial neural network by training the ANN with the model parameters as inputs and the condition of the subjects, normal or having any of the COPDs, as outputs.

Electronic auscultation of lung sounds is another efficient technique to evaluate the condition of respiratory system. In this thesis, a new algorithm is proposed for classifying the lung sound signals. As lung sound signals are non-stationary, instead of the conventionally used mutually exclusive time and frequency domain representations, wavelet transform representation which has two dimensions with time and frequency as co-ordinates was used. Lung sound signals were decomposed into the frequency subbands using wavelet transform and a set of statistical features was extracted from the subbands to represent the distribution of wavelet coefficients. An ANN based system with wavelet coefficients as inputs, trained using the resilient backpropagation algorithm, was implemented to classify the lung sounds to one of the six categories: normal, wheeze, crackle, squawk, stridor, or rhonchus. The proposed scheme of lung sound classification would serve as an aid for physician in diagnosis of respiratory diseases.

Study of respiratory system under physical exercise is extremely useful for understanding the complex nature of respiratory control. The concept that respiration is controlled by optimal control of work rate has been assumed by many investigators. It was observed that the respiratory flow rate is sinusoidal under normal breathing, but
under exercise it changes to trapezoidal and then to rectangular wave. Expressions for breathing rate have been derived under each of these conditions based on the optimum control of work rate concept. Experiments were performed to verify the validity of these expressions and there is good agreement between the theoretical and experimental values. It was also seen that the work rate due to elastic and non-elastic elements of the respiratory system exhibits opposite trends, and breathing occurs at a rate corresponding to the total minimum work rate.