Chapter 7
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CONCLUSIONS

7.1 Summary of the Thesis

The primary function of the respiratory system is to maintain normal gas tensions of the blood. This is achieved by absorption of oxygen from the inspired air and the giving up of carbon dioxide in the expired air. The fundamental mechanisms involved in attaining this goal are ventilation, diffusion, and circulation. The assessment of the type and degree of functional impairment is extremely important in the diagnosis, management and prognosis of pulmonary disorders. Analysis of respiratory signals as well as mathematical modelling can aid the physician in these issues. This thesis has addressed certain investigations performed using novel techniques for the diagnosis, and analysis of human respiratory system.

Physicians rely on PFTs for analysis and detection of abnormalities in lung function of respiratory patients. Of the various types of PFTs, spirometry is the most commonly used technique. Spirometry is the measurement of the flow and volume of air entering and leaving the lungs. Interpretation of the results of spirometry should be based on the careful study of the numerical values, as well as the graphic representation. The interpreter should be familiar with the standards, particularly as they apply to the equipment and technique used, as well as the reference values of parameters. Computation of reference values of lung parameters is very intricate due to the dependence of these values on various factors. In this thesis, artificial neural network has been applied
to obtain the reference values of important lung parameters. A two layer feedforward neural network with 80 neurons in the hidden layer was trained using Levenberg-Marquardt algorithm with age, gender, height, weight, and body mass index of normal subjects as inputs and their lung parameters as outputs. Performance of the trained neural network was verified and it was observed that this technique provides reference values having better proximity to actual values than the conventional predictive equations. The proposed method was applied only for people aged between 15 and 25 hailing from South India.

Maximum expiratory flow-volume (MEFV) curve is widely used for assessment of pulmonary function and it appears to be uniquely determined by the mechanical properties of the lung. MEFV curve represents a very complex relationship between maximal flow and changes in lung volume. A novel method of diagnosis of COPD based on model parameters extracted from the MEFV curve was presented in this thesis. The model parameters of normal subjects and patients having COPD were estimated using GA based optimisation. Usefulness of the model parameters 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 diagnostic tool for assessing the health of a respiratory system. 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. WT provides a new perspective in analysis of lung sounds, since it can decompose them into multiscale details, describing their power at each scale and position. 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.

Exercise testing allows evaluation of the lungs and heart under conditions of increased metabolic demand, so that abnormalities not readily defined in terms of decreased flows, volumes, or diffusing capacities may be defined. Exercise testing has lot of other applications also. In this thesis, the exercise study was limited to study of the variation in breathing rate when the subjects undergo controlled exercise. Identifying the change in inspiratory flow rates at different stages of exercise, equations have been derived for the breathing rate. The predictions of breathing rate were validated against laboratory data collected from volunteer subjects. It was also seen that the work rate due to elastic and non-elastic elements of the respiratory system exhibits opposite trends, and the breathing occurs at the rate corresponding to the total minimum work rate.

7.2 Suggestions for Future Work

Some of the suggestions, which may be taken up by researchers for future work, are summarized below.

1. Evaluation of spirometric reference values can be extended for all age groups. This may require collection of spirometric data of a large number of people covering all age groups who do not have any respiratory abnormality, and subsequent training of the ANN.

2. It was observed that model indices of MEFV curve are useful for diagnosis COPD. Optimisation techniques may be applied for online evaluation of parameters and hence for effective utilization of the method.
3. Statistical parameters evaluated from the wavelet coefficients are used to represent the frequency distribution of lung sounds. Investigations may be carried out with other statistical parameters such as variance of the coefficients in each subband to observe for any improvement in classification efficiency.

4. The study performed on the variation of breathing rate with physical exercise may be extended to predict an individual’s ability to do any particular work. It may also be used to predict an individual’s maximum physical capacity. Further investigations on variation of breathing rate based on optimum force concept may also be performed.