CHAPTER 7

CONCLUSION AND FUTURE WORK

This chapter summarizes and concludes this research work and also focuses on the scope for future enhancements.

7.1 CONCLUSION

In this work an intelligent framework for a CAD system was proposed for the detection and classification of lung disorders from chest CT slices. The CAD system framework is tailored for different lung disorders like ILDs, Pulmonary TB and pleural disorders. This work is carried out with the aim of providing a second opinion for the radiologists in diagnosing lung diseases. The proposed CAD systems are evaluated using chest CT slices of diseases like emphysema, GGO, fibrosis, miliary TB, cavitary TB and pleural disorders like pleural effusion and pneumothorax. Three different CAD systems are implemented and validated as a part of this research work. The first work involves a CAD system for the classification of ILDs. The second work is a CAD system for the detection and classification of pulmonary TB while the third research work involves a CAD system for classifying the pleural disorders like pleural effusion and pneumothorax,

**Contribution 1:** The first work is aimed at classifying ILDs namely emphysema, fibrosis, GGO and military TB using a SVM classifier that has been optimized using PSO. The QWF filter parameters are also optimized using the PSO. The results obtained from the first work show that when the
SVM and QWF parameters are optimized using the PSO, the false positives are reduced. The performance parameters accuracy, precision, sensitivity and specificity of the system have improved compared to the existing system without the PSO. In this work instead of classifying the CT slices into the five classes, the ROI blocks are classified into the five classes. This helps to identify if other diseases (from among the five classes) are also present on different blocks of the same slice. When a single query slice is applied to the CAD system, the lungs are segmented and divided into blocks and the disease pattern in each block is extracted as a feature vector. Then each block is individually classified. If the percentage of blocks classified as normal is more then it implies that the disease is in its initial stage. Similarly if the blocks are classified as two disease classes then it indicates that the lung is affected by two types of ILDs. So this work will be useful for differential diagnosis, especially because many ILDs exhibit similar radiological patterns and so the final disease diagnosis can be concluded by the physician, based on the radiologist's report, physical symptoms and laboratory reports.

**Contribution 2:** The second work is aimed at classifying pulmonary TB. Cavitary and miliary TB are two forms of commonly occurring TB. Miliary TB is a primary form of TB that is not very clearly visible in CXRs. Cavitary TB commonly occurs in the upper lobes of the lungs and so are occluded by the ribs and collar bones. So CT plays a vital role in the detection of TB. The CAD systems in literature have all been developed using CXRs. This work has used chest CT slices and so the results are understandably higher in comparison with the existing systems. Textons were originally used for natural images but in this work they are applied for medical images. Textons are used in this work to reduce the dimensionality of the image which in turn reduces the computation time. Gabor filters are least affected by noise. If noise affects a CT slice then the radiological patterns may not be visible. Therefore Gabor filters are used in this work. Gabor filters are also invariant
to illumination, rotation, scale and translation. Also the LGXP histogram
descriptor is not a single histogram but is formed by grouping together several
histograms. This technique of grouping and using several histograms instead
of using only one histogram has the advantage of being phase invariant.
Hence in this work a CAD system is developed with a feature extraction
scheme, having the combined advantages of gabor filters, textons and
histogram. This is a major contribution of this work. The CAD system has
been implemented to aid the radiologists in the diagnosis of pulmonary TB
(Sluimer et al 2006). The results indicate that the texton based LGXP out
performs the system using only LGXP.

**Contribution 3:** The third work has focused on extracting and classifying
pleural disorders namely pleural effusion and pneumothorax. The
segmentation scheme used in this work is an automated technique for
classifying pneumothorax as no schemes are available in literature. Another
contribution of this work is the calculation of the percentage of the lung that is
affected by the pleural disorder.

**7.2 SCOPE FOR FUTURE ENHANCEMENTS**

The work on classification of ILDs using a SVM classifier can be
further extended to consider the effect of adding CT slices corresponding to
more number of ILDs. Some ILDs exhibit a group of radiological patterns.
Hence a system that identifies only a single pattern will not be useful to detect
and classify such diseases. So the radiological patterns exhibited by different
ILDs can be studied and the classifier can be trained to identify those features.

In the work on classification of cavitary and miliary TB, some of
the cavities which are thin walled could not be detected by the CAD system.
So as a future work a CAD system can be developed to classify cavitary TB
based on the wall thickness of the TB cavities. A CAD system can also be
developed for the classification of other types of pulmonary TB like TB pleurisy and primary tuberculosis pneumonia. The lung lobes can be segmented and the lung lobes in which the TB cavities are present can also be determined. This is done because though cavities can be present in all the lobes the TB cavities are present mainly in the upper lung lobes.

In work on the extraction and classification of pleural effusion and pneumothorax, it was observed in some CT slices, the ribs surrounding the lungs are not continuous. In such cases, the pleural effusion region could not be extracted, resulting in wrong classification of those slices. So the segmentation scheme can be further improved to enhance the classification results. Also there are different types of pleural disorders like hemothorax where the pleural space is filled with blood, pyopneumothorax where the pleural cavity is filled with pus and air and hydropneumothorax where there is accumulation of fluid and gas in the pleural cavity. This work can be extended to classify hemothorax, pyopneumothorax and hydropneumothorax diseases.