ABSTRACT

Computer Aided Diagnosis (CAD) is one of the major research areas in the field of medical imaging and radiology. CAD systems are used by radiologists for detection and differential diagnosis of different types of abnormalities. The output of a CAD system can be used by radiologists along with laboratory results to get a second opinion before making a diagnosis. CAD systems are developed based on an understanding of the radiological patterns, which have to be observed in the image, for a particular disease.

In this research work three approaches have been proposed for improving the diagnosis of lung disorders from chest computed tomography (CT) slices. The first approach is for the classification of Interstitial Lung Diseases (ILDs) such as emphysema, fibrosis, ground glass opacities (GGOs) and miliary tuberculosis (TB) using a particle swarm optimized support vector machine (SVM). The second approach is a novel feature extraction scheme for the classification of cavitary and miliary TB. The third approach is a scheme to extract and classify the pleural effusion and pneumothorax regions in lung CT slices.

The first work is classification of ILDs where a CAD system is developed and in which the feature extraction system and the classifier are optimized. The chest CT slices that have already been diagnosed by an expert are preprocessed and the lung regions are segmented using region growing
algorithm. The segmented lung is divided into 32 x 32 blocks and all blocks containing less than 75% of the lung region are discarded. Twenty three histogram features are computed using the Gray Level Histogram (GLH) and three features are computed using the Quincunx Wavelet Frame (QWF) decomposition. Particle Swarm Optimization (PSO) is used to optimize the order and the number of decomposition levels of the QWF. The GLH and QWF features are grouped to form a feature vector.

The feature vectors that are extracted are applied to the SVM classifier. The SVM classifier learns from the feature vector space to find the decision boundaries among five classes of lung CT patterns (emphysema, fibrosis, GGO, miliary TB and normal) using a one-versus-all (OAA) approach. The PSO is used to optimize the cost function and the standard deviation of the SVM classifier. This results in an optimized SVM classifier that has been trained to differentiate between five classes of disease patterns.

The query slice to be classified is applied to the CAD system and the lung regions are segmented. The segmented lung regions are divided into 32 x 32 blocks and the GLH and QWF features are extracted. The feature vector is formed and is applied to the trained SVM which classifies each block based on the training received. Instead of extracting a specific region in the segmented lung as the ROI region, the entire lung region is being considered. Hence early disease diagnosis is possible as the radiological pattern can be identified in at least a few of the ROI blocks. Thus the probability of missing out a pathologically affected region is minimized. The system has achieved an average accuracy of 96.01%.
The second work on classification of cavitary and miliary TB involves the development of a CAD system with a novel feature extraction scheme. The chest CT slice dataset that is already diagnosed by a radiologist and consisting of cavitary TB, miliary TB, normal and CT slices affected with other diseases is considered as the training dataset. The lung regions are segmented and the cavities are extracted using the region growing algorithm to determine if they are TB cavities or non TB cavities. All slices with non TB cavities are converted into texton images. The texton images are convoluted with a gabor kernel to obtain a gabor image consisting of a magnitude part and the phase part. The gabor phase image is alone selected and converted into a Local Gabor XOR Pattern (LGXP) image from which the LGXP histogram descriptor is computed. Five statistical texture features mean, variance, skewness, kurtosis and energy are extracted from the LGXP histogram descriptor. These five features form the feature vector that is applied to a probabilistic neural network (PNN) classifier for training. The PNN has three output classes representing miliary TB, normal lung and other diseases.

The query CT slices are segmented to extract the lungs. Then cavity regions are extracted to determine if they are TB or non TB cavities. In case CT slices with TB cavities are identified, then the slices are classified as cavitary TB. The remaining slices are transformed into a texton based LGXP histogram from which the statistical features are extracted. The extracted features form the feature vectors that are provided to the trained PNN for classification into the three output classes namely, miliary TB, normal slices
and CT slices affected by other diseases. The results exhibit an average accuracy of 94.79%.

The third work on the extraction and classification of pleural effusion and pneumothorax regions involves the modeling of a CAD system using arithmetic and morphological operations. The challenge in this work is in extracting the ROIs. The lung CT slices that are diagnosed by a radiologist are segmented using basic thresholding and morphological operations to extract the lung parenchyma. Next the ROIs of pleural effusion are extracted followed by the extraction of the ROIs of pneumothorax. Ten shape and texture features area, convex area, equivalent diameter, mean, eccentricity, solidity, perimeter, entropy, smoothness and standard deviation are extracted from the ROIs. When ROIs are not extracted from a CT slice (as in the case of normal lung CT) then the features are extracted from the segmented lung regions. The extracted features are applied to the PNN for training. The PNN is trained to identify the feature vectors belonging to the four classes – pleural effusion, pneumothorax, normal lung and chest CT slices affected by other diseases. When the query CT slice is applied, based on the training received, the PNN classifies the query slice into the four classes. The classification results exhibit an accuracy of 94.25% for pleural effusion and 96.67% for pneumothorax.