ABSTRACT

Tuberculosis (TB) is a communicable disease for which an early diagnosis is essential to control the disease. The microscopy-based TB screening is the conventional method employed for TB identification and provides significant benefit to large number of TB burdened communities across the globe. Manual screening using microscope is tedious and requires highly trained experts. Besides huge variability in sensitivity, manual screening for the identification of disease causing agent is a labor intensive task. Further, it is time consuming and depends on patient’s level of infection and requires large number of images to be analyzed in one slide. Hence there is a need to automate the diagnostic process to improve the sensitivity and accuracy of the test.

The sputum smear positive and negative images (N =100) recorded under standard image acquisition protocol are considered for this work. The non-uniform illumination in microscopic digital TB images due to light source optics and camera noise degrades the visual perception of these images. In this work, pre-processing step to correct the non-uniform illumination using retrospective techniques such as Surface Fitting Method (SFM), Multiple Regression Method (MRM) and Bidirectional Empirical Mode Decomposition (BEMD) has been attempted. The most appropriate illumination correction method is evaluated by calculating the error and statistical measures. Multifractal analysis that describes both local and global pixel distribution in an image is performed to further validate the methods.

The pre-processed sputum smear images are subjected to
segmentation using level set formulation of active contour method. This level set formulation aid in the automatic detection of the object contours, where the initial curve can be assumed anywhere in the image. The TB objects thus obtained are segregated into bacilli and non-bacilli by extracting geometric shape descriptors. This procedure is automated using neuro fuzzy classifiers including Adaptive Neuro Fuzzy Inference System (ANFIS) and Complex valued Adaptive Neuro Fuzzy Inference System (CANFIS).

The non-bacilli objects in the sputum smear images consist of outliers and overlapping bacilli. An attempt has been made to separate these overlapping bacilli using Multi-phase Active Contour method (MAC), Marker Controlled Watershed (MCW) and Method of Concavity (MOC). The best match is found between the objects separated from the above methods and the true (already existing) bacilli from the images.

To further improve the automation process of distinguishing the pathological images from the normal, geometric shape descriptors, Hu and Zernike moments are extracted. The most significant features are derived using Kernel Principal Component Analysis (KPCA). Further the most significant geometric and moment features are subjected to classification using ANFIS, CANFIS and Differential Evolutionary Extreme Learning Machines (DE-ELM). The performance measures of the classifiers are evaluated by computing the confusion matrix and diagnostic accuracy in terms of sensitivity, specificity, accuracy and F-measure.