Identification of Tuberculosis bacilli using Image Processing

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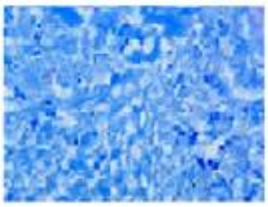
ABSTRACT
Tuberculosis is currently the world's leading cause of death from a single infectious disease. In the case of an epidemic the only option of diagnosis remains is the sputum examination. To improve the diagnostic process we are developing an automated method for the detection of tuberculosis bacilli in clinical specimens, preferably sputum smears. Our proposed method makes use of image processing techniques and neural network classifiers for the automatic identification of TB bacilli using Auramine stained specimens of sputum. The developed system , currently shows 93.5% sensitivity for identifying individual bacilli. There are numerous TB bacilli with active pulmonary TB in the patient's sputum. The overall diagnostic accuracy of the patients with positive smear is expected to be very high. Some potential benefits of automated screening for TB are accurate and rapid diagnosis, increased population screening and reduced health risk.

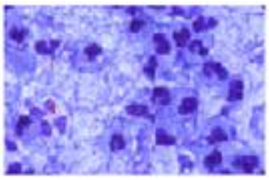
Keyword : fluorescence microscopy, pattern matching, tuberculosis.

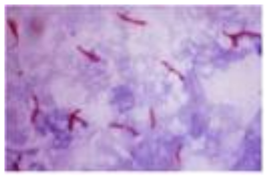
1. INTRODUCTION
Tuberculosis (TB) is the main cause of death due to infectious disease. It is found that one-third of the world's population are carriers of this disease, originating about 10 million cases of active TB worldwide and approximately 2 million deaths annually. The main cause of the infection can be due the increasing susceptibility of human population affected by AIDS, poverty, other factors weakening the immune systems of populations in developing countries and the socially marginalised groups in developed countries. Another key to the advancement of the disease lies in the exceptional evolutionary abilities of Mycobacteria.

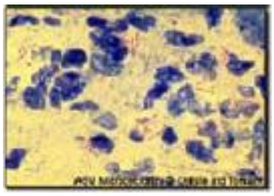
One of the WHO recommended methods to detect AFB after staining with Auramine-O is Smear fluorescent microscopy. The normal visual slide screening for identification and counting of AFB is a tedious, labor intensive task. The low quality , inconsistent slide staining technique, debris, variation in human perception , and fatigue lead to sensitivity as low as 40%, especially in the scanty specimens of the stained sputum which usually take longer time to culture itself .


(a) Bacilli


(b) Detected Bacilli


(c) Increased Bacilli


(d) Acid Fast Bacilli


(e) Zheil Neelsen Stain

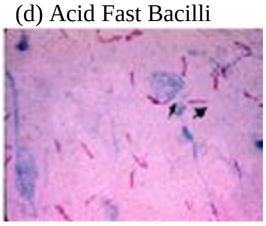

(f) Sputum Examination

Fig 1.Various tuberculosis bacteria and bacilli

2. LITERATURE SURVEY
In early days, the tuberculin skin test (TST) was the only test available to diagnose latent TB infection. The test has remained unmodified for the last 60 years. The TST is still being used to identify patients latently infected with tuberculosis despite its inaccuracies.[3]

People who are suspected of having active TB may be given a number of different tests to confirm the damage caused by the infection or to identify the organisms responsible for the infection.

2.1 Skin Test
The skin test often remains positive for life after initial infection with TB, and therefore the test can be false positive in patients successfully treated for TB in the past. [3]

2.2 Radiological examinations
Chest x-ray is used to check for abnormalities in lung of the people who have symptoms of TB disease. The results of a chest x-ray may be suggestive of TB; however the technique is not specific as many other diseases can produce similar features. Therefore the results from a chest x-ray cannot confirm that a person has TB. It is difficult to distinguish past, cured TB from current active disease similar to the skin test since scarring in the lungs remains after a previous TB infection .[3]

2.3 Smear Microscopy
Examination of sputum for the detection of acid-fast bacilli (AFB) is the simplest laboratory test

In India, Ziehl–Neelsen stain, also known as the acid-fast stain is presently used technique for tuberculosis detection. In general, about 10 minutes is needed to prepare the slide using this technique. The technique lacks sensitivity and consequently clinicians must wait for the culture results as much as three days because this bacilli takes 5 to 20 hours to duplicate itself. Manual screening for the bacillus identification involves a labour intensive task with a high false negative rate.[2]

From the literature survey, it is found that the following methods are used by different researchers for Tuberculosis disease detection &analysis:

1) Morphology using opening & closing disk type algorithm method.

2) Edge detection using Sobel Algorithm.

3) Back propagation neural network.

The identification process is done in two steps :

1) Identification by colour: At this stage a thresholding of the green channel in relation to red channel is performed in order to extract only those regions whose colour is characteristic of staining the bacilli.

2) Identification by shape: From the green channel, edge detection using canny operator is executed. Several morphological operators are used in order to draw the forms of the bacillus and eliminate the region whose shape is not characteristic of the bacilli

3 DATA FLOW CHART

The procedure of identification of bacilli using the algorithm is shown in fig. 2

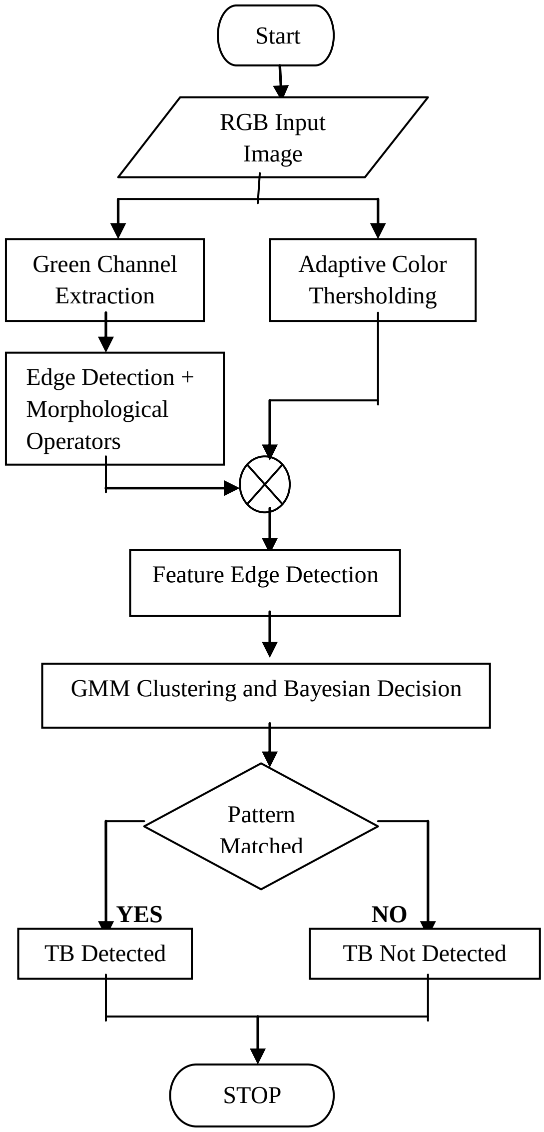


Figure 2. Schematic procedure of the stages required for bacillus/non-bacillus discrimination

4 PROPOSED SYSTEM

As shown in figure 2. Initially an RGB image is obtained of the sputum with the help of a photomicroscope..With the obtained image the following processes are carried on which would help in the identification of our required bacilli.

4.1 Green Channel Extraction

Auramine O is the fluorescent dye used in the proposed system. The fluorescence of M. tuberculosis bacilli is in the range between green and yellow up to white. Bacilli have a length between approximately 1 and 10 micrometer and a width between 0.2 and 0.6 micrometer, and is straight, curved or bent in shape. Individual bacilli may display heavily stained areas and zones of alternative staining.

This information is important and is used for segmentation and identification processes. Figure 3 shows that the bacilli present an intense brightness in the green frequencies (550–625 nm) but less brightness in other colour frequencies.

It is also verified that the sputum debris and other particles do not fluoresce in the green frequencies but it is seen that they are brighter in the red frequencies (650–750 nm). The blue frequencies (400–550 nm) do not include significant information for distinguishing the bacill.

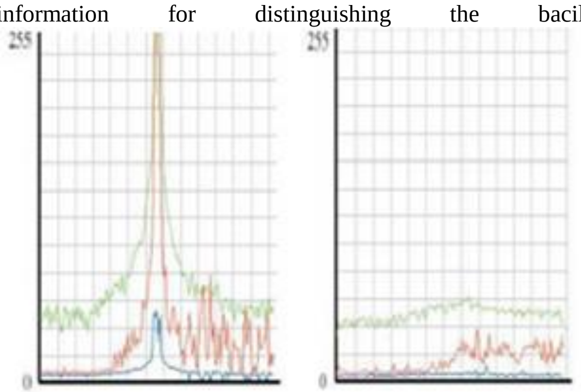


Figure 3. RGB colour profile of the sputum sample

4.1 Edge Detection And Adaptive Thresholding

The first stage of the edge detection process is a segmentation procedure. Canny's operator (σ = 1) is used to detect the edges with only the employed green channel. The pixels with local maxima gradients are then retained.

Later, a thresholding is applied to retain those edges whose magnitude of gradient is higher than a low threshold and that have at least one pixel above a high threshold. The threshold is thus set by observing the green colour intensity of bacillus region of the slide as well as in background region. The resulting objects may have broken edges. Such edges can be closed by applying a morphological closing operation.

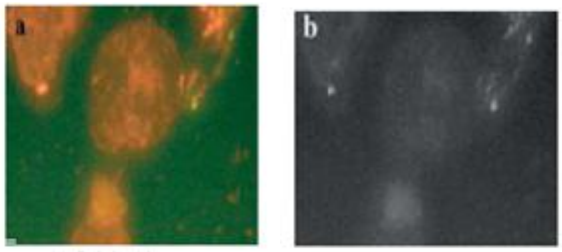
Opening and closing are used to eliminate image details that are smaller than the structuring element.

4.2 Filtering

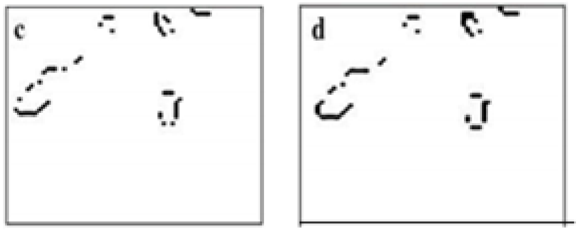
After the image segmention, only those objects are retained which have the same bacillus colour. An identification process must now be performed to determine which of them are true bacilli. Therefore, the remaining objects are filtered according to their area and eccentricity, rejecting those objects whose area is too small or too large or whose eccentricity is very low, i.e. the object is too round to be a bacillus.

4.3 Feature Extraction

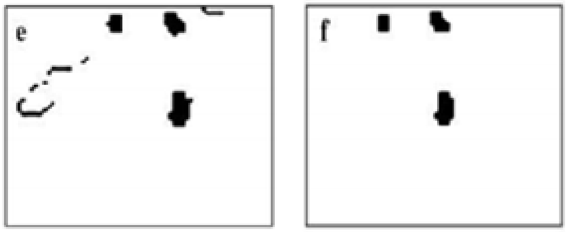
Tuberculosis images that are to be analysed are characterized by a large diversity of debris in terms of both shape and size. Thus, the classification scheme used consists of a single class of bacilli and a rejection class. Some debris objects that present in a similar shape and size as bacilli might increase the misclassification rate. The defined procedure gives the most restrictive distribution class for bacilli in such a way that a great majority of the debris can be eliminated. The features evaluated for bacillus characterization are area, compactness, major and minor axis lengths, eccentricity, perimeter, solidity.



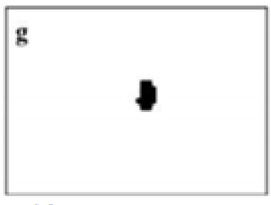
(a) Original image (b) Green Channel



(c) Edge Detection (d) Closing



(e) Filling Closed Regions (f) Opening



(g) Color Segmentation

Figure 4.Details of the sputum sample

4.4 Clustering

Clustering analysis is done for recognizing the bacilli present in clusters and finding the degree of match with the bacilli present in reference dataset. K-means clustering algorithm is used. The algorithm first obtains the number of clusters that define the training bacillus data set, using the chosen descriptors.

The concept of neural networks is used in the recognition process. Neural network is used for pattern recognition, feature extraction, image matching. Back propagation is a form of supervised training.

The basic back propagation algorithm is based on minimizing the network error using the derivatives of the error function.

5 SCOPE AND APPLICATIONS

Tuberculosis (TB), with millions of victims each year is still the infectious disease that is responsible for the most deaths in the world today. Image processing techniques provide a good tool for improving the manual screening of samples**.**

Faster and more appropriate methods for the detection of tuberculosis can be used in the medical institutes and also in many bio technology laboratories.

6 CONCLUSION

The literature survey done in this paper provides a new insight in detection of tuberculosis. A technique for analyzing fluorescence images of sputum using Image Processing is proposed.The technique involves segmentation followed by an identification procedure.The segmentation allows the elimination of a great amount of unwanted objects, and therefore only those characterized to have a similar colour as that of the bacilli are retained.

There is a scope for working on development of innovative, efficient & fast interpreting algorithms which will help doctors in detecting the deadly disease.

Work proposed can be extended for development of hybrid algorithms such as genetic algorithms & neural networks in order to increase the recognition rate of the final classification process.

7. REFERENCES

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