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A Novel Approach for Automated Color Segmentation of Tuberculosis Bacteria through Region Growing

M. Hemalatha
Assistant professor,
Dept of ECE,
S.V College of Engineering.

A.V. Kiranmai
Assistant professor,
Dept of ECE,
S.V Engineering College for Women.

D.Sreehari
Assistant professor,
Dept of ECE,
S.V Engineering College for Women.

Abstract:

Medical image investigation is extremely difficult because of quirks of restorative calling. Object acknowledgment with information mining methods has helped specialists in the event of restorative crises for the picture examination, design ID and treatment. More than 180 million individuals kicked the bucket and more than 33% of the populace is bearer of Mycobacterium Tuberculosis (TB) microorganisms according to the WHO insights. Division of TB from the re colored foundation is extremely difficult because of clamor and flotsam and jetsam in the picture. In this venture, a mechanized division of tuberculosis bacterium utilizing picture handling systems is introduced. Shading division with locale developing watershed calculation is proposed for the bacterial ID.

Keywords:

Tuberculosis Bacteria, Bright field Microscopy, Region Growing Watershed Segmentation, Feature Extraction.

1. INTRODUCTION:

Mycobacterium Tuberculosis Bacteria leads to Tuberculosis. Every year 9 million new tuberculosis cases are found and death of a tuberculosis person is observed every second. more than one third of the world population are the carriers of this pathogen Koch bacterium which spreads through air, infected cow and milk and seen more in smoking people. It affects more organs of the body including skin, bone, brain, kidneys and lungs [6-10]. People suffer from various health problems like prolonged cough, breathing problem, bronchitis, fever, weight loss, tiredness etc. Mycobacterium tuberculosis is resistant to many drugs and more than 50% are killed [11-12].

TB Bacteria can only be seen under microscope, they are unicellular and colorless. ZN-Stain has been applied on the smear to identify them under microscope. The size of bacteria is in millionth part of a meter. Automated segmentation methods have several advantages compared to the laborious, prolonged and expensive methods. Several researchers have addressed the segmentation of TB bacterial objects. There are 2 major methods in screening the smear microscopic samples: Bright field microscopy and Fluorescence microscopy (FM). The Bright field microscopy is the historical, oldest and longest procedure to examine the TB samples. Bright field microscopy is less expensive, more popular in developing countries and the cost can be affordable by the low-income patients. Smears are ZN stained and bacilli appear in pink or magenta color over blue background. Costa considered Bright field microscopy images for the TB bacterial identification from the blue background.

They segmented the background using Hue histogram and R minus G (R-G) color space. 10-binary histogram of R-G channel was used to binarize the image. Khutlang segmented ZN stained TB image with pixel classifiers treating each pixel as an object. Sad pal segmented the TB positive images from the dataset and 3D probability density histogram function has been used to measure the likelihood the pixel as TB for a combination of primary colors red, blue and green. Fluorescence microscopy (FM) has also been used to screen the TB objects and the equipment is very expensive compared to Bright field microscopy. Veroupoulos [16] used 15 direct auramine stained and 50 centrifuged smears for FM to identify the TB objects. Canny edge algorithm with boundary tracing and Fourier descriptors for feature extraction has been used. Forero used green channel of RGB with canny edge detector, shape descriptors, hue moments and Fourier descriptors for TB object segmentation. In this paper, we propose an automated pre-processing technique that uses seeded region-growing

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watershed color segmentation method to segment the suspected TB bacteria or object from the stained background. Segmentation and Feature extraction is one of the major tasks in image processing. The potential and distinguished morphological features, geometrical features and Hu moments are extracted from each segmented object.

II. MATERIALS ANDMETHODS:

Microorganisms are 0.1 to 0.5 micron in breadth and 1 to 6 micron in length. TB bacteria are rod shaped bacilli. Bacilli are approximately 1 to 10 µm in length and 0.2 to 0.6 µm in width. Identification of TB bacterium in the early stages is very important for the treatment as bacteria grows exponentially in the living medium. In hospital routine, two methods are largely used to identify the bacteria: Viable microorganism counting method and a Microscopic counting method. A viable microorganism counting method takes a longer time and is expensive, while a microscopic counting method lacks the accuracy and needs an expert round the clock. This necessitates an automated method that recognizes and counts the bacteria. Generally, the bacteria are colour less, must be tinted with some stains. Usual stains employed are Gram stain for ordinary bacteria, Ziehl-Neelsen (ZN) stain for TB bacteria, Leishman stain for Blood samples etc. In hospitals, sputum smears are prepared by placing 50 or 100 µl of the sample on the glass slide and stained with ZN stain to segment and fix the bacteria on the smear.

Manual screening of TB under a microscope lacks accuracy and sensitivity as it depends on many factors like smear preparation, staining method, lens, resolution and a domain expert. ZN stained tuberculosis bacterium gains pink to magenta color over blue background. MB/Bact [19-20] is used in some of the hospitals for the recovery of mycobacterium from various clinical specimens and culture preparation of TB bacteria with maximum duration of 8 weeks. This is an expensive method and cannot be affordable by the people from weaker section of the society. In this paper, an automated approach has been proposed, wherein, the required input images are captured by CCD camera which is fixed on top of the microscope at 100X magnification. Each image is of size 2080 * 1542 pixels. The elapsed time is varied among the images based on the smears prepared and to design a better automated algorithm for different color and intensity of images.

516 complex TB images of high color variance with lot of noise and debris are considered as input images for experimental purpose. 2379 positive and negative TB samples are tested. Color segmentation is very challenging as image contains lot of noise and debris and bacillus shape alone was not a discriminate feature.

III. PROPOSED METHOD:

Mycobacterium tuberculosis bacilli appear in the image as pink or magenta color over blue background. They vary in wide range of length from 1µm to 10 µm which is of great task for the segmentation and object validation. They are rod shaped and also appear as curved or straight rods. They also appear in beaded form which makes identification task difficult. The Fig. 1, represents the different input images of different smears with different color range and covered with maximum noise, debris and unwanted objects that makes object segmentation more difficult. Fig. 2, represents the proposed architecture for Segmentation of tuberculosis bacterium. It consists of Image pre-processing, Image segmentation and Feature extraction. The color conversion with noise removal is done in preprocessing followed by image segmentation through watershed algorithm. The region validation and object validation is also being done for better segmentation. Seeded Region growing algorithm is used for segmentation. Feature extraction is done with most distinct geometric features and invariant Hue moments.

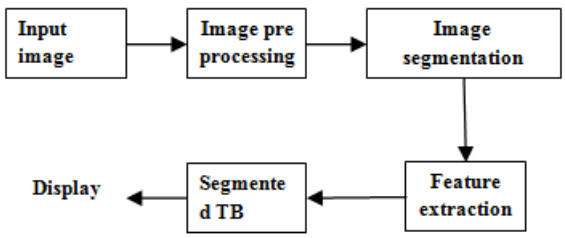

Figure: Block diagram of proposed system

A. Image Pre-processing:

Image segmentation based on color thresholding and noise removal is proposed in the first phase of our algorithm. Human recognition system can segment thousands of colors. Combination of primary colors red, blue, green is based on the Cartesian coordinate system which is used to represent the digital color images.

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HSI and Lab represent the perceptual attributes of Hue, Saturation and Intensity and hence more suitable for color image processing. The input images are read and converted to gray, Lab, YCbCr and HSI images. The gray images are used for contour based region growing watershed image segmentation. The color range values are extracted from all 3 planes of YCbCr, Lab, HSI and image is thresholded in all 3 planes and concatenation done to check the existence of the object pixel point in all 3 color planes. The Lab color is chosen in our proposed segmentation approach. After morphological hole filling operation, object elimination is done to remove the noise particles of area > 800 pixels and axis ratio<0.6. Statistical properties are extracted from each of the segmented N objects. Fig. 3, shows the different stages of color stained bacterial segmentation.

B. Automated Image Segmentation with Region-Growing Watershed Algorithm:

The seeded region growing is one of the simple methods used for segmentation. The seeds are given as input to this method. Objects to be segmented are assigned with seed points. The seed point grows with each iteration based on the neighbour pixel value of the region. The mean value of the region and pixel intensity difference is calculated and measure of similarity is computed. The pixel with lesser difference is selected with each iteration till all the pixel of the object is assigned. In our proposed approach the 8 neighbour contour isperformed in region growing. Counter based region growing watershed approach has been used to segment the TB object from images.

Centroid of the object is calculated and its Region of Interest (ROI) isextracted. If centroid is within the ROI, 300 x 300 pixels of gray image has been cropped and seed points are calculated using median. Contour based region growing watershed algorithm is executed to segment the object as BW image. The morphological object validation is done to remove the irrelevant objects. The valid ROI is masked on the gray image for feature extraction of each object. Fig. 4, shows the different stages of watershed segmented TB objects. It represents seed point selection on object, watershed contour and object segmentation. Fig. 6, shows the segmented objects after watershed segmentation of Fig. 3. Contour based Region growing watershed image segmentation algorithm has been proposed for the segmentation of stained magenta color bacteria from the blue background. ZN stain is applied on the colorless bacteria which gains magenta color. The algorithm is as shown below.

C. Feature Extraction:

Shape is the major descriptor of the Tuberculosis bacterium. It is rod shaped and varies in length from 1µm to 10 µm which makes segmentation more difficult. From Figure 1, it is observed that lot of debris and noise is present in the input image and improper staining method mask the bacterium. Hence colour segmentation alone cannot segment the bacterium.

Discriminate Geometrical features like area, perimeter, solidity, circularity, major axis, minor axis, eccentricity, axis ratio (minor/major) with invariant Hu moments were considered for each bacterium. Geometrical features and Hu moments are extracted [32-34] from segmented objects of TB image and feature vector prepared for classification.

C. Algorithm: Contour based Image segmentation (RGB inputimage, Feature vector output):

Step 1. Read the input RGB image.

Step 2. Convert the RGB image to Gray and goto step 9.

Step 3. Enter the options " 1 ycbcr 2 Lab 3 HSI " and convert the input RGB image to respective user options.

Step 4. perform color based (option 1 or 2 or 3) segmentation to select ROI as BW image.

step 5. Perform morphological operation on BW to "fill holes"

Step 6. Perform noise removal based on area(>800) and axis ratio(minor/major <0.6) to filter unwanted objects and debris.

Step 7. Measure statistical properties of objects.

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Step 8. Count the valid number of objects(N) step 9. For all i=1..N objects, perform.

a) If the object centroid is not within ROI goto step 9 Else crop the ith object with 300 x 300 pixels from gray image.
b) Perform the Centroid validation using median as contour based Region growing seed point.

c) Perform contour based Region growing watershed segmentation(BW).

d) Perform morphological Object validation.

e) Mask the valid ROI on gray image for feature extraction of each object.

f) Perform Feature extraction (geometric and Hu features extraction).

g) Prepare Feature Vector by concatenating Geometric and Hu features.

h) Mask the valid object on color RGB input image for final object representation.

Step10. Output / Export all the Feature Vectors of the objects in the input image to perform classification.

IV.EXPERIMENTAL RESULTS:

As show the experimental results of the above figure is watershed segmented TB objects image and the seeded region growing is one of the simple methods used for segmentation. The seeds are given as input to this method.

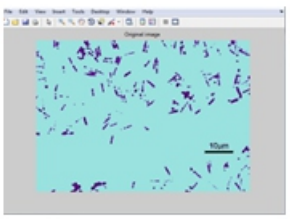

Fig1: Input image

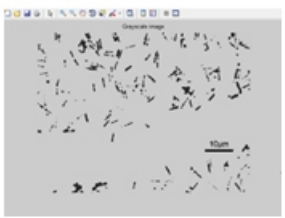

Fig2: gray scale image

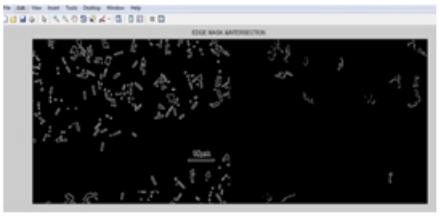

Figure3: Edge detection image

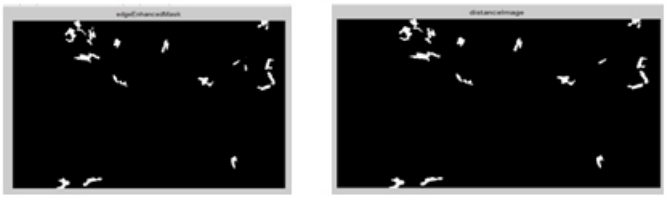

Figure4: segmented TB bacteria images

V .CONCLUSION:

Contour region growing watershed segmentation based method has been proposed for the segmentation of tuberculosis bacteria from the blue background. Three color representations Lab, HSI, YCbCr used for color segmentation. Segmentation algorithm removes the maximum amount of debris and noise of the input image resulting in bacillus shaped objects. Morphological objects and feature vectors given as an input for classifiers. The proposed method has been tested for large number of TB images with best results which can assist the doctors in medical diagnosis and treatment.

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