© 2014 IJIRT | Volume 1 Issue 8 | ISSN: 2349-6002

DIGITAL HISTOPATHOLOGY IMAGE ENHANCEMENT USING EDGE DETECTION

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Abstract- **This project aims at enhancing digital histopathology images to provide pathologists valuable assistance on examining the tissue slides. Inconsistencies in the preparation of histopathology slides make it difficult to perform quantitative analysis on their results. In this paper edge detection is used for overcoming many of the known inconsistencies in the staining process .Segmentation is done to simplify an image into something that is more easier to analyse and process. Based on pixel values images are segmented. The segmented images are then RGB color classified by the nearest neighbor rule. After these process, the processed image is then edge detected using Canny Edge Detector, Sobel Edge Detector and LoG Edge Detector. The output image from all the edge detection technique is then analysed and compared as to see which gives the best result. Various Histopathology slides have been taken and an analysis is made on how the disease is found out using the edge detected image.**

Index Terms **– Histopathology image analysis; Image Segmentation; RGB Color Classification; Edge Detector.**

I. INTRODUCTION

Histopathology is the diagnosis of disease by visual examination of tissue under the microscope. Tissue slides are analysed by treating it with stains that have selective affinities for different biological substances.The majority of stains absorb only light and the stained slides are therefore viewed using a microscope with a light illuminating a sample from below. If no stain is present then the tissue doesn't absorb any light and passes through it. Areas where the stain has adhered to a substance in the tissue will absorb some of the light. The amount of light absorbed depends on many factors.The two most prominent factors that affect the intensity of slide are the stain added to the slides in the initial treatment and the subsequent storage and handling of the slide.

The absolute color values of a slide have many influences only one of which is the biological components we wish to retrieve.This biological component is the actual amount of the cellular substance to which a particular stain will attach. There are generally two stain namely hemotoxylin and eosin which are treated with the tissue slides. Hemotoxylin selectively stains nucleic acid a blue-purple color and eosin stain proteins with a bright pink color. A large number of methods presented in the area of automatic image analysis of color histopathology images bypass the problem of constancy by transforming the color images to gray images. These are then edge detected so that the shapes of the cells present would be clearly visible. By viewing the shapes of those cells in the tissue one can clearly tell what the disease is.

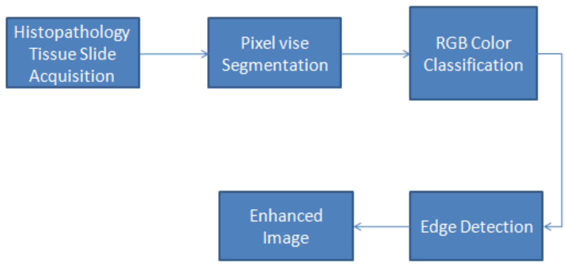

Fig.1Block Diagram

II. PREVIOUS WORK

Histopathalogy slide enhancement is done using many techniques..[1]presented a novel approach to stain normalization in histopathology images. The method is based on non linear mapping of a source image to a target image using a representation derived from color deconvolution. It proposed the use of a color-based classifier that incorporates a novel stain color descriptor to calculate image specific stain matrix. [11] presented a new color-based approach for automated segmentation and classification of tumor tissues from microscopic images. The method comprises of color normalization to reduce the quality variation of tissue image within samples from individual subjects or from different subjects,automatic sampling from tissue image to eliminate tedious and time-consuming steps and principal component analysis (PCA) to characterize color features in accordance with a standard set of training data. The algorithm is evaluated by comparing the performance of the proposed fully-automated method against semi-automated procedures.

[12] used a statistical method known as Distance Weighted Discrimination was used to find the optimal separation direction between melanoma and nevi based on this feature space. They have greatly improved the ability to quantitatively analyze histology slides .These methods are easy to implement and computation time is much improved over NMF methods.

[13] proposed non negative matrix factorization to solve the general color mixing problem. NMF are more general, there are no closed form solutions for these problems, forcing the solutions to be computed numerically. The NMF based logarithms attempt to factor the OD matrix into V and S with the constraint that all elements be non-negative. This method works well with an abundance of information as in the multispectral images they used in their paper, but tend to have inconsistent convergence when only three spectral components are available.

III. PROPOSED SYSTEM

A detailed description on the implementation aspects of the proposed work is given below

A.SYSTEM MODULES

The entire work is divided into the following modules for better understanding of study and implementation.

1.*IMAGE ACQUISITION*

The first step of this work is to acquire a medical image which is to be processed and analysed. The image taken in this research is Chronic Myeloid Leukemia(CML).CML is a cancer of the white blood cells.

2.IMAGE SEGMENTATION

Segmentation divides an image into its constituent regions or subjects. The level to which the subdivision is carried depends on the problem being solved. That is, segmentation should stop when the objects of interest have been isolated.There is no reason to carry segmentation past the level of detail required to identify those elements. Segmentation of nontrivial images is one of the most difficult tasks in image processing. Segmentation accuracy determines the eventual success or failure of computerized analyzing procedure. For this reason, considerable care should be taken to improve the probability of rugged segmentation. Segmentation algorithms for monochrome images generally are based on one of two basic properties of image intensity values: discontinuity and similarity. In the first category, the approach is to partition an image based on abrupt changes in intensity such as edges. The principal approaches in the second category are based on partitioning an image into regions that are similar according to a set of predefined criteria. The goal of segmentation is to simplify an image into something that is more easier to analyse and process. Every pixel in an image is allocated to one of a number of categories. A good segmentation is typically in which:

- Pixels in the same category have similar graysacle of multivariate values and form a connected region.
- Neighbouring pixels which are in different categories have dissimilar values.

In this work Region based segmentation is used. The similarity taken into consideration is pixel vise segmentation. Pixelvise segmentation scans an image and groups its pixels into components based on pixel connectivity; that is,all pixels in a connected component share similar pixel intensity values and are in some way connected with each other . Once all groups have been determined, each pixel is labelled with a gray level or a color (color labelling) according to the components it was assigned to. Extracting and labelling of various disjoint and connected components in an image is central to many automated image analysis applications.

After completing the scan, the equivalent label pairs are sorted into equivalence classes and a unique label is assigned to each class. As a final step, a second scan is made of the image,during which each label is replaced by the label assigned to its equivalence classes. For display, the labels might be different gray levels or colors.

3.RGB COLOR CLASSIFICATION

Classification refers to clustering or grouping data items into similar tests. This information is often useful in the analysis step for any signal/data processing system. Image classification is similar to general data classification, but it may be different depending on the application in which it is used.A human analyst attempting to classify features in an image uses the elements of visual interpretation to identify homogenous groups of pixels that represent various features for the classes of interest. It was discovered that human color perception is based on a triad of fundamental colors,RGB, which has remained the most fundamental color model used in digital image processing. This forms the basis of the most fundamental color model system called the RGB. Infact, once an image is loaded into a computer's memory system,most of the time it is stored as three layers of pixels corresponding to R,G,B respectively. In order to work with RGB images in any programming environment,basic information about size and data precision representation must be obtained before actual processing starts. An RGB image also called truecolor image of screen dimensions M rows and N columns has a size of M*N*3 pixels. Here 3 represents the three layers of red,green and blue intensities. RGB Color Classification is done by nearest neighbour rule. Images are formed by pixels. Each pixel is classified according to the pixel values of colors. If a pixel has the value closest to the Red pixel, then that pixel comes under the group of red color. Similarly all the pixel values are grouped under each color. The image which has more amount of several individual colors are taken and they are processed further.

4.EDGE DETECTION:

An edge can be defined as "a sudden change of intensity in an image". In binary images, an edge corresponds to a sudden change in intensity level to 1 from 0, and vice versa. This, essentially, represents high-frequency components in the image and, thus, extracting them would involve some procedure to extract high frequencies from the image. This implies that once high-frequency components (i.e., edges) are found, they are threshold to logic 1 in the image while all other pixels are set to zero. Too many edges represent a "rough" image, while too few would correspond to a relatively "smoother" image. At the pixel, the intensity changes from 0 to 255 at the direction of the gradient. The magnitude of the gradient indicates the strength of the edge. The edge detection techniques used in this project is Sobel Edge Detector, Canny Edge Detector and Laplacian Of Gaussian operator(LOG).

SOBEL EDGE DETECTOR

The Sobel operator performs a 2D spatial gradient measurement on an image and emphasizes regions of high spatial frequency that correspond to edges. Typically, it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The operator consists of a pair of 3*3 convolution kernels. One kernel is simply the other rotated by 90. These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image to produce separate measurements of the gradient component in each orientation of that gradient. The gradient magnitude is given by

$$|G| = \sqrt{(Gx^2 + Gy^2)} \qquad (1)$$

An approximate magnitude is computed using

$$|G| = |Gx| + |Gy| \qquad (2)$$

The angle of orientation of the edge is given by

$$\theta = \arctan\left(\frac{Gy}{Gx}\right) \qquad (3)$$

Sobel detector has slow computational capability but as it has large kernel it is less sensitive to noise. Errors due to effect of noise are reduced by local averaging within the neighbourhood of the mask.

CANNY EDGE DETECTOR

Canny Edge Detection is an optimal edge detection technique as it provides good detection,clear response and good localisation. It is widely used in current image processing techniques with further developments. It takes as input a grayscale image, and produces as output an image showing the positions of tracked intensity discontinuities. The operator works in a multistage process.

STEPS INVOLVED

NOISE REDUCTION BY SMOOTHING

Noise contained in the input is smoothed by convolving the input image I(i,j) with Gaussian filter G. Mthematically the smooth resultant image is given by

$$F(i,j) = G * I(i,j) \qquad (4)$$

FINDING GRADIENTS

In this step we detect the edges where the change in grayscale intensity is maximum. Required areas are determined with the help of gradient of images. Sobel operator is used to determine the gradient at each pixel of smoothened image. Sobel operators in i and j direction is given by

$$D_i = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \text{ And } D_j = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

These sobel masks are convolved with smoothed image and giving gradients in i and j directions.

$$G_i = D_i * F(i,j) and\ G_j = D_j * F(i,j) \quad (5)$$

Therefore edge strength or magnitude of gradient of a pixel is given by

$$G = \sqrt{(Gi^2 + Gj^2)} \quad (6)$$

The direction of the gradient is given by

$$\theta = \arctan\left({G_j}/{G_i} \right) \quad (7)$$

NON MAXIMUM SUPPRESSIONS

Non maximum suppression is carried out to preserve all local maxima in the gradient image. For a pixel M(i,j);

- First round the gradient direction θ nearest 45 degree, then compare the gradient magnitude in positive and negative directions i.e. If gradient direction is east then compare with gradient of the pixels in east and west directions say E(i,j) and W(i,j) respectively.

- If the edge strength of pixel M(i,j) is larger than that of E(i,j) and W(i,j), then preserve the value of gradient and mark M(i,j) as edge pixel, if not then suppress or remove.

HYSTERISIS THRESHOLDING

The output of a non maximal suppression still contains the local maxima created by noise. Instead of choosing a single threshold, for avoiding the problem of streaking two thresholds t_{high} and t_{low} are used. For a pixel M(i,j) having gradient magnitude G following conditions exists to detect pixel as edge

- If G <t_{low}then discard the edge.
- If G >t_{high}then keep the edge.
- If t_{low}< G <$t_{high}$and any of its neighbours in a 3*3 region around it have gradient magnitudes graeter than , keep the edge.
- If none of pixel (x,y)'s neighbour have high gradient magnitudes but atleast one falls between t_{low} and t_{high} search the region to see if any of these pixels have a magnitude graeter than t_{high}. If so keep the edge.
- Else discard the pixel.

LAPLACIAN OF GAUSSIAN OPERATOR

It is a gradient based operator which uses the laplacian to take the second derivative of an image. It uses both the Laplacian and Gaussian operator so that tha Gaussian operator reduces noise and Laplacian operator detects the sharp edges. The operator normally takes a single gray level image as input and produces another gray level image as output.
The Gaussian function is defined by the formula:

$$G(i,j) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\text{-}(\frac{i^2+j^2}{2\sigma^2}) \quad (8)$$

The LoG operator is computed from:

$$LoG = \frac{\partial^2}{\partial i^2} G(i,j) + \frac{\partial^2}{\partial j^2} G(i,j) = \frac{i^2 + j^2 - 2\sigma^2}{\sigma^4} \exp\left(-\frac{i^2+j^2}{2\sigma^2}\right) \quad (9)$$

It generates responses that do not correspond to edges,so called false edges and the localisation error may be severe at curved edges. The general algorithm is as follows

- Smooth the image using a Gaussian. This smoothing reduces the amount of error found due to noise

- Apply a two dimensional Laplacian to the image
- Loop through every pixel in the Laplacian of the smoothed image and look for signchanges. If there is a sign change and the slope across this sign change is greater than some threshold, mark this pixel as an edge. Alternatively, you can run these changes in slope through a hysteresis (described in the Canny edge detector) rather than using a simple threshold.

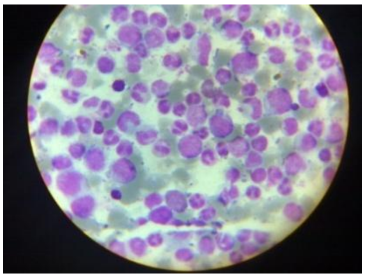

Fig.2 Acquired Image

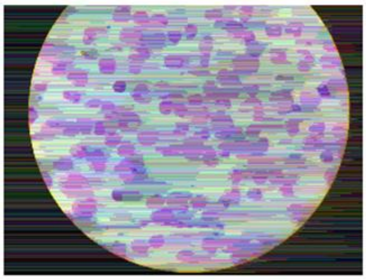

Fig.3 Segmented Image

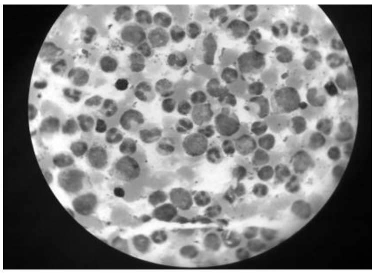

Fig.4 RGB Color classified image

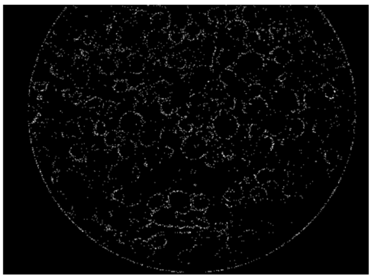

Fig.5 Sobel Edge Detected Output

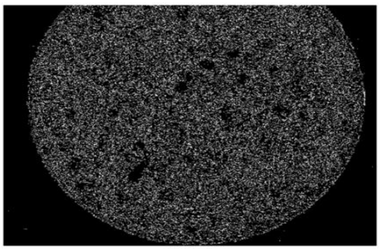

Fig.6 Canny Edge Detected Output

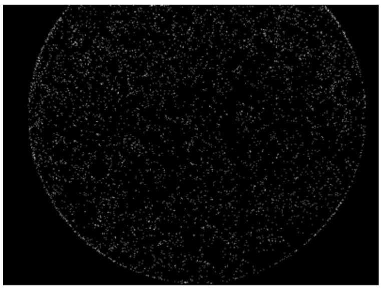

Fig.7 LOG Operator Output

V. CONCLUSION

From the edge detected image one can identify the structure of the cells present in it and identify the health issue. This paper concentrates on shape features alone and are thus not affected by color irregularities. Those circular shape cells in abundance indicates that the person has Chronic Myeloid Leukemia Thus the tissue slides are enhanced using various edge detection techniques such as Sobel, LaplacianOf Gaussian and the result are compared with each other. Sobel Operator is sensitive to noise. The increase in the noise to the image will eventually degrade the magnitude of the edges. LoG Operator is also susceptible to noise. Thus it is commom to see spurious edges than obvious edges. Among them Canny Edge detector has more advantages such as less sensitive to noise, adaptive in nature and good localization.

VI. FUTUREWORK

Although the techniques above have their own advantages there are some flaws in them so it has to be improved. It finds application in MRI Image, edge detection of river regime, real time facial expression recognition. Canny algorithm can be improved by detecting the images in colour image rather than converting to gray scale image. Further Hough Transform can be implemented which corrects the spurious intensity discontinuities by linking procedures to assemble edge pixels into meaningful edges.

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