A Realistic Medical Image Segmentation of Abnormal HIV in Blood Cells Using Morphological Operations

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***ABSTRACT* - Images are soft copies of real world objects. Image can be represented in the area of digital processing, which can be said as another reproduction of an object. Basically Segmentation is one of the processes of partitioning a digital image into multiple regions and extracting meaningful regions for the future image analysis. The prime objective of this research work is to segment the abnormal HIV cells in blood using morphological operations. The boundary region of the HIV cells in blood is detected and segmented using different morphological operations. Finally Image Quality Assessment(IQA) has been carried out using various evaluation measures.**

Keywords: Cell Segmentation; Morphological Operations; PSNR; MD; NAE; NK; AD

I.INTRODUCTION

Images are imitations of real world substances [3]. Segmentation is the process of dividing a digital image into several regions and extracting significant regions known as regions of interest (ROI) for the future image analysis [4]. Morphological operation is a large set of image processing operations that process images depending on shapes. In morphological operation a structuring element is applied as an input image and creates an output image of the similar size and the value of each pixel in the output image is based on the assessment of the corresponding pixel in the input image with its neighbors [3]. By choosing the shape and size of the neighborhood the morphological operation can be constructed which is sensitive to definite shapes in the input image.

II. RESEARCH METHODOLOGY

The goal of segmentation is to divide the image into homogeneous regions. Here, the system architecture of our proposed work shown in the fig-1.

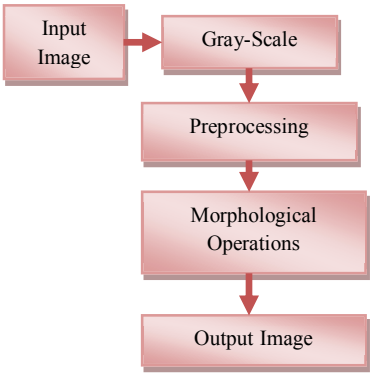

Fig1. System Architecture

III PREPROCESSING

The ultimate goal of pre-processing is to improve the image data that suppresses unwanted distortions or improves some image features important for further processing. It is also an important feature for enhancing the visual appearance of an image [12]. Pre-processing mainly involves grayscale contrast enhancement, noise removal, image resampling, mathematical operations and manual correction. In this proposed work noise removal pre-processing technique has been performed by median filter [12].

A. Median Filter

Median filtering is a nonlinear operation. It is more efficient than other noises because it reduces noise and also preserves edges [4]. Here the noise can be described as any disturbance that modifies the actual image. There are several ways to add noise into an image. There are various types of filters to condense the noise such as linear filtering, adaptive

filtering and median filtering [3]. Median filtering is a simple and powerful non-linear filter while compared to every other filter and it is very easy to implement [1]. Median filtering is a common image enhancement technique. When compared to linear techniques this filtering is less sensitive. It removes salt and pepper noise without reducing the sharpness of an image [13].

IV. SEGMENTATION

Segmentation is the process of dividing a digital image into multiple regions and extracting significant regions known as regions of interest (ROI) for the future image analysis [13]. Image segmentation has emerged as an essential phase in image-based applications. Thresholding is a very important method for image processing. It produces uniform regions based on the threshold criterion T. The thresholding operation can be thought of as an operation, such as

$$T=T\{x, y, A(x, y), f(x, y)\} \quad (1)$$

In which the exacting region is detected using this segmentation method along with the thresholding operation. Edge plays a very vital role in image processing application in which they provide an outline of the object. In the physical plane, edges correspond to the discontinuities in depth, surface orientation, changes in material properties, and light variations. When an edge is detected, the redundant details are removed, while only important structural information is retained.

A. Uses of Segmentation:

- *Better understanding of an image*
- *Object recognition*
- *Image editing*
- *Image compression*
- *Boundary estimation of ROI(Region of Interest).*

V. MORPHOLOGICAL OPERATIONS

Morphological operation is a broad set of image processing operations that process images based on shapes [3]. In morphological operation a structuring element is applied as an input image and creates an output image of the equal size [15]. In a morphological operation, the assessment of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood the morphological operation can be constructed which is responsive to specific shapes in the input image [14]. The number of pixels removed or added from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological operations the condition of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image.

A. Adjust

The adjust function is used to adjust the image intensity values so that the adjusted image is good in contrast compared to the initial input image [15]. By performing adjust operation , the visual quality of the image is enhanced.

B. Erosion

Erosion is a morphological operation method which is used to remove pixels from the boundaries of an image [3]. Erosion operation is also one of the foremost morphological processing. Erosion "thins" or "shrinks" the objects in binary images [1]. As in dilation, the way to shrink and the extent is restricted by a structure element. The mathematical definition of erosion is same like dilation. If A is eroded by B, recorded as A $\ominus$ B, and is defined as

$$A \ominus B = \{z|(B)_z \subseteq A\} \quad (2)$$

The erosion of A by B is the set of every point z such that B, translated by z, is contained in A. B is for structuring element.

Erosion can also be used to eliminate small spurious bright spots in images. It can also be said that it removes salt noise in images. Although it removes noise, the rest of the image has been degraded drastically.

C. Dilation

Dilation enlarges the components of an image. Dilation is the operation of "thickening" or "lengthening" in binary image [1]. This special way and the degree of thickening are controlled by structural elements. Mathematically, dilation can also be defined as set operation. A is dilated by B, written as A$\oplus$B, is defined as

$$A \oplus B = \{z|(\hat{B})_z \cap A \neq \emptyset\} \quad (3)$$

Among them, $\emptyset$ represents empty set, B is for the structure element, and $\hat{B}$ is for the reflection of group B. In precise, that A is dilated by B is the set combined of the origin positions of all structural

elements. Subsequent to mapping and translation, B at least has one overlap with A.

This equation depends on reflecting B about its origin and changing this reflection by z. The dilation of A by B is then the set of all displacements z, such that $\hat{B}$ and A overlaps by at least one element.

D. Opening

Opening usually smoothes the contours of an object and remove thin protrusions [1]. The opening of a set A by structuring element B cab be defined as

$$A \circ B = (A \ominus B) \oplus B \qquad (4)$$

Thus the opening of A by B is erosion of A by B, which is followed by a dilation of the result by B [3].

E. Closing

Closing tends to smooth sections of contours but combines narrow breaks and long, thin gulfs and removing small holes and filling gaps in the contour [1]. The closing of a set A by structuring element B is defined as

$$A \bullet B = (A \oplus B) \ominus B \qquad (5)$$

Therefore the closing of A by B is dilation of A by B, which is followed by an erosion of the result by B [3].

F. Maxima & Minima

In an image, each and every tiny variation in intensity represents a regional minima or maxima [14]. An image may have several regional minima or maxima but it has only a distinct global maxima or minima. To find these fluctuations few functions are used.

i. Regional Minima & Maxima: The functions imregionalmin and imregionalmax are used to identify all regional minima or regional maxima [15].

ii. Extended Minima & Maxima: The functions imextendedmin and imextendedmax are used to find all regional minima or maxima which are less than or greater than a specified threshold [15]. It is used to only identify areas of the image where the change in intensity is tremendous; that is, the difference between the pixel and neighboring pixels is less than (or greater than) a definite threshold [14]. These functions take a grayscale image as input and give a binary image as output. In the resulted binary image, the regional maxima or minima are set to 1 and all other pixels are set to 0.

iii. H-Maxima & H-Minima: To find significant minima or maxima the functions imhmax and imhmin are used [15]. These functions, denotes a contrast criteria or threshold level, h, which suppresses the entire maxima whose height is fewer than h or whose minima are larger than h [14]. Thus the functions imhmax and imhmin produce an altered image.

iv. *Imposing a Minima:* Emphasizing specific minima (dark objects) in an image is done using the function imimposemin [15]. This function uses morphological reconstruction to eradicate all minima from an image excluding the minima which is specified. It locates the values of pixels indicated by the marker image to the lowest value supported by the datatype (0 for uint8 values [14]). This function also modifiess the values of all the other pixels in the image to remove the other minima.

G. Watershed Transforms

The image has many objects of diverse sizes that are touching each other. Object recognition in an image is an instance of image segmentation. Mostly the Watershed transform is used to segment the touching objects [14]. The Watershed transform finds mountains and valleys, that is, high and low intensities in an image [14]. In short the watershed transform detects intensity "valleys" in an image.

The pixels which correspond to the watershed regions are given a label matrix containing nonnegative numbers [15]. The watershed function is used to return this. The pixels which do not drop into any watershed region are given a pixel value of 0. The best way to picture a label matrix is to change it to a color image by using the label2rgb function [15]. In the colored version of the image, each labeled section displays in a different color and the pixels that split the regions display white.

Maximizing the contrast of the objects of interest to minimize the amount of valleys found by the Watershed transform gives a better result. A general technique for contrast enhancement is the integrated use of the top-hat and bottom-hat transforms.

i. Top-hat & Bottom-Hat Transforms: The top-hat transform can be defined as the variation between the original image and the opening of its original image

[1]. The opening of an image is the group of foreground parts of an image that fit a particular structuring element. The bottom-hat transform can be defined as the variation between the original image and closing. The closing of an image is the group of background parts of an image that fit a particular structuring element [14]. The top-hat and bottom-hat transforms of the original image is returned by the functions imtophat and imbothat [3].

The function strel is used to create structuring element [3]. We can specify the shape of structuring element based on how the object of interest in our image looks. The size of the structuring element is always depends on an estimation of the average radius of the objects in the image [15]. The top-hat image has the "mountains" of objects that fit the structuring element. The bottom-hat demonstrates the gap between the objects [3].

H. Morphological Reconstruction

Morphological reconstruction is an efficient technique for extracting meaningful information regarding shapes in an image [14]. Morphological reconstruction is a dominant operation in Mathematical Morphology that inserts the idea of connectivity in images, both for binary and gray scale [15]. Morphological reconstruction can be used for constructing an image from tiny components [14]. It is also used for discarding features from an image, without changing the shape of the objects in the image. It is also used in applications such as removing shadows from images, detecting connected paths in a map or network, identifying language scripts etc. The morphological reconstruction method is based on a source image, a marker image, and marker points.

- **Source Image**— It is the reference image which is used in the morphological reconstruction.
- **Marker Image**— The reconstruction process takes place on the marker image, which is created by applying erosion or dilation on the source image.
- **Marker Points**—Marker points are user-mentioned points in the image that specifies where the reconstruction process should begin.

i. Reconstruction by Erosion

Reconstruction by erosion is performed by reconstructing dark regions in a grayscale image and gaps in a binary image. Initiating from the marker points, the neighboring pixels are reconstructed by distributing the darkness value. Reconstruction by erosion begins with the minimal valued pixels of the marker and reconstructs the neighboring pixels varying from the minimal valued pixel to the image maximum value [14].

I. Clear Border

The clearborder operation suppresses light structures connected to image border [15]. It suppresses structures that are lighter than their surroundings and that are connected to the image border. The function imclearborder is used to clear borders of objects or ligher structures [15]. In case of binary images, this particular function removes objects which touch the image margins. In case of grayscale images, lighter regions (higher intensity values) which touch the image border get removed [14]. In addition for grayscale image the overall intensity level is reduced in addition to suppressing border structures by using the function.

VI. EVALUATION MEASURES

Evaluating the image quality is a necessary characteristic in image processing. Commonly popular evaluation techniques such as Maximum Difference(MD),Peak Signal to Noise Ratio(PSNR), Normalized Absolute Error(NAE), Normalized Cross Correlation(NK) and Average Difference(AD) are considered to evaluate the quality of proposed methodology.

A. Maximum Difference(MD)

The large value of MD means the image is poor quality[11]. MD is defined as

$$\mathrm{MD} = \mathrm{Max}(\ |x(m,n)\hat{x}(m,n)\ |) \qquad (6)$$

B. Peak Signal–To-Noise Ratio(PSNR)

PSNR is the evaluation standard of the reconstructed image quality, and is important feature [3]. The small value of PSNR means that image is poor quality. PSNR is defined as follow

$$\mathrm{PSNR} = 10\log\frac{255^2}{\mathrm{MSE}} \qquad (7)$$

Where 255 is maximum possible value that can be attained by the image signal. Ideally it is infinite. Practically it is in the range of 25 to 40 dB.

C. Normalized Absolute Error (NAE)

Normalization is the process of separating statistical error in repeated measured data. Normalization is sometimes based on a property. Quintile normalization, for instance, is normalization based on the magnitude (quintile) of the measures. NAE is defined as

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i.j) - y(i,j)|}{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i.j)|} \qquad (8)$$

The large the value of NAE means that image is poor quality [11].

D. *Normalized Cross-Correlation (NK)*

The closeness between two digital images can also be quantified in terms of correlation function. Normalized Cross-Correlation (NK) measures the similarity between two images [16] and is given by the equation .

$$NK = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)\times y(i,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j))^2} \qquad (9)$$

E. *Average Difference (AD)*

The difference is visual property that makes an object distinguishable from other objects and the background [16]. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other within the same field of view. Because the human visual system is more sensitive to contrast than absolute luminance, we can perceive the world similarly regardless of the huge changes in illumination over the day or from place to place.

$$AD = \sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k})/MN \qquad (10)$$

VII. RESULT

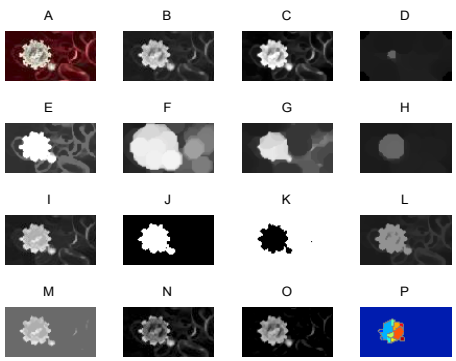

Fig. 2 (A) Input RGB Image (B) Enhanced Gray-scale Image (C)Adjust (D)Erosion (E) Reconstruction (F) Dilation (G) Close (H) Open (I) Fill (J)Extended Maxima (K) Extended Minima (L)H-Maxima (M)H-Minima (N)Tophat (O)Clearborder (P)Watershed

Table I. Values of Evaluation Measures

Morphological Operations	Evaluation Measures				
	MD	***NAE***	***PSNR***	***NCC***	***AD***
Adjust	13	0.2463	25.2444	1.0926	4.4528
Erode	224	0.6974	11.9953	0.1645	34.5213
reconstruct	146	0.2926	17.2717	0.5661	14.487
Dilate	0	1.8291	7.0161	1.6186	-90.5455
Close	0	0.5134	16.8433	1.233	-25.4161
Open	223	0.4849	14.9682	0.4271	24.0060
Fill	0	0.0467	30.2691	1.0285	-2.3117
extended-max	241	0.997	10.6496	0.0046	49.3562
extended-min	242	0.9825	10.6480	0.0045	48.637
H-max	100	0.1495	22.2917	0.7759	7.4019
H-min	0	1.2677	11.3461	1.2781	-62.7556
Top-hat	84	0.4705	18.2340	0.6271	23.2894
clearborder	84	0.5586	18.5146	0.6874	27.6512
watershed	241	0.973	10.7687	0.0183	48.166

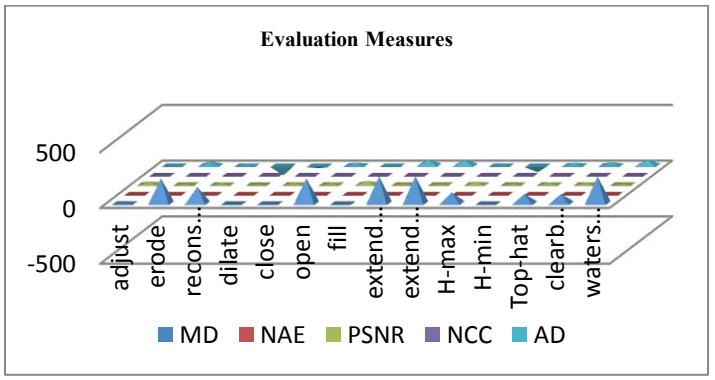

Fig. 3. Result of Evaluation Measures

VIII. CONCLUSION

The mathematical morphological operations are mostly implemented to improvise the contrast of an image. In this research work abnormal HIV cells in blood has been segmented from the input image using morphological operations. These operations perform well in segmenting the cells from the image based on intensity and shape. The main advantage of morphological operation is that it clearly spots the regions of an image so that the image is improvised for further analysis. Finally Image Quality Assessment(IQA) has been done using various measures which shows that different morphological operations perform differently based on intensity of an image. Not a single morphological operation can be said as best, because each operation gives a different view and each one works differently depending on the image values. But for definite it can

be concluded that morphological operations perform well in the field of medical image processing.

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