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A comparative analysis of watershed and edge based segmentation of red blood cells

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ABSTRACT

Background: Useful information which is helpful in the diagnosis of various disorders is obtained from the analysis of individual blood cells. **Aim:** To perform a comparative analysis between edge-based segmentation and watershed segmentation on images of the red blood cells. **Method:** The images to be used for the analysis were gotten from published research works. A database that contains both images was created in the Matlab environment. Edge-based segmentation and watershed segmentation were performed on the images. The edge based segmentation involves finding ridges, lines and contours along the images, while the watershed segmentation involves opening and closing reconstruction of overlapping features in images. MATLAB 2010a was used as the tool box for performing the segmentation process. **Result:** The value of correlation for segmentation with edge and watershed stood at 0.9499, 0.9198, respectively. Also, in terms of deviation, values for both were 65.846, and 60.317 respectively, and also in terms of area, the values were 39520 and 4467 respectively. Finally, in terms of mean, the values were 187.06 and 17.006. **Conclusion:** Watershed segmentation outperforms edge based segmentation in terms of image statistics and performance, which can help physician and medical practitioners to identify possible blood disorder.

Key words: Watershed, red blood cell, segmentation, edge-based, Matlab, reconstruction

INTRODUCTION

The erythrocytes are the most numerous blood cells in the human body, and it also called red blood cells. The red blood cell functions as a carrier of oxygen throughout our body.[1] The normal red blood cell in our body is divided into four categories of ages, which are newborn, children, women and men. The average amount of red blood cells for each category is about 4.8-7.2 million per cubic millimeter, about 3.8–5.5 million per cubic millimeter, about 4.2-5.0 million of these cells per cubic millimeter and 4.6-6.0 x 10^6 per cubic millimeter respectively. Red blood is measured by the amount of haemoglobin in our blood. For medical image segmentation, it is very important for the clinical diagnosis and quantitative analysis to segment the interesting medical image accurately.[2] The complexity and diversity of medical images, uniform gray-scale intensity features, and the fact that image itself is also easily influenced by noise or other factors make medical image segmentation quite difficult; therefore, there is a need for a systematic medical image segmentation method.[2] The integration of mobile communication and biomedical instrumentation technology plays an important role in Telemedicine as doctors away from the system can also get the health status of their critical patients.[3] The major concern in medical field is how to detect malign changes from such medical images, the detection of tumours, arteriosclerosis, or other changes, and the extent of deformation in particular medical image data with the use of information technology. This issue is an aspect to be accomplished in medical field as discussed.[4]

Image segmentation is the process of analyzing images and enhancing their performance in order to perform simple or multiple operations, in order to segment or break or classify the image into smaller parts or bits which are important ingredients during processing of images.

METHODOLOGY

Image acquisition

Figure 1 shows a typical red blood cell image used for analysis. The images to be used for the analysis were gotten from published research works. The resulting image data is an ordinary 2D image, a 3D volume, or an image sequence depending on the type of sensor.[5] A database that contains both images was created in the Matlab environment. The image was called from the database using Matlab algorithm.

Watershed segmentation

Separating touching objects in an image is one of the more difficult image processing operations.[6] The watershed transform is often applied to this problem.[6,7] The watershed transform finds "catchment basins" and "watershed ridge lines" in an image by treating it as a surface where light pixels are high and dark pixels are low[6]. Segmentation using the watershed transforms works better if you can identify, or "mark," foreground objects and background locations. Marker-controlled watershed segmentation follows this basic procedure [7].

Edge based segmentation

Analysis of edge- based segmentation of images was done in order to get the corresponding values of images which include statistics and analysis. For image detection, registration, more robust feature points are referred than noisy edge information. Another criterion named “edge correlation” is introduced which incorporates the canny edge, the canny edge is used in the equation below.[8]

$ER_n(j\ x\ y\ ) = \quad_{j=1}\ (x,y),$

where n indicate the number of scales involved in the multiplication, and j is the initial scale for the edge correlation.

Based on the edge correlation, the direct multiplication of wavelet transform data at adjacent scales is employed to distinguish important edges from noise.[8] In Matlab, filtering involves using a special filter type, which helps to identifying the range of form of filtration. The table below describes the different filter types and their description.

Watershed algorithm [9]

Step 1: Read image into Matlab
Step 2: Pre-process image
Step 3: Pick image pixels and values identical to image
Step 4. Pick centre 1 = -10
Step 5. Compute centre 2 = - centre 1
Step 6: Compute distance

$$Distance = \sqrt{(2 \times (2 \times centre\ 1)^2}$$

Step 7: Compute radius

$$Radius = \frac{Distance}{2} \times 1.4$$

Step 8: Compute line:

$$Lineisamatrixvaluesthatrepresenttheimages$$

$$Floor: Itroundsofftheelementsof Atothenearestintegerlessthanorequalto A$$

$$Ceil: Itroundsofftheelementsof Atothenearestintegerlessthanorequalto A$$

$$Line = [floor\ (centre\ 1 - 1.2 \times radius)\ \ ceil\ (centre\ 2 \times 1.2 \times radius)]$$

$$[x, y] = meshgrid\ (Line\ (1) : Line(2)\ );$$

$$Bw1 = sqrt\ (x{-}centre1).\hat{}2 + (y{-}centre1).\hat{}2 \quad <= radius$$

$$Bw2 = sqrt(x - centre1).^2 + (y - centre1).^2 \leq radius$$

$$Bw = Bw1\ or Bw2$$

Step 9: Compute the distance transform of the complement of the binary image

$$D = bwdist(\sim Bw)$$

Step 10: Complement the distance transform, and force pixels that do not belong to the objects to be at negative infinity

$$D = -D$$

$$D(-Bw) = negativeinfinity$$

Algorithm for canny edge based segmentation[10]

Step 1: Convolve image f(r, c) with a Gaussian function to get smooth image f^(r, c).

f^(r, c)=f(r,c)*G(r,c,6)

Step 2: Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtain as before.

Step 3: Apply non-maximal or critical suppression to the gradient magnitude.

Step 4: Apply threshold to the non-maximal suppression image.

Statistical analysis

The software used for the analysis was Matlab 7.10a. Matlab is a strongly built programming environment, with statistical features and analysis. It is used to generate features in images, and give statistical result and analysis concerning the image. The statistical analysis done was carried out by comparing the performance of both segmentation method against each other and the values related in percentage.

RESULTS

System design and implementation

This involves loading the image anywhere in the computer to get the image. The first stage of any image processing is getting the image. After the image has been gotten, the various tasks which involve processing the image, analyzing the image can now be performed. It is also important to note that if image has not been gotten the processing cannot take place, therefore rendering the work useless. An interactive interface was developed which was used to carry out the process.

Matlab implementation

Any image which comes into the Matlab environment has a definite value, which is identified by Matlab. In image processing Matlab enhances the image and generates its value using the im-read function. This enables further processing. Image components are also gotten in the work environment, after its value has been gotten. This is very important because it helps to enhance image processing. These components are identifiable and are attached to each image, this implies that for every image coming into the Matlab environment. It has a definite component, which makes it very useful in analysis. In figure 2.0 shown above, the user interface is used to load in image into the Matlab environment and the corresponding image is then picked up. Segmentation types are selected which could either be watershed or edge based. The resulting panel on the right hand side shows the results generated and the corresponding plot is made.

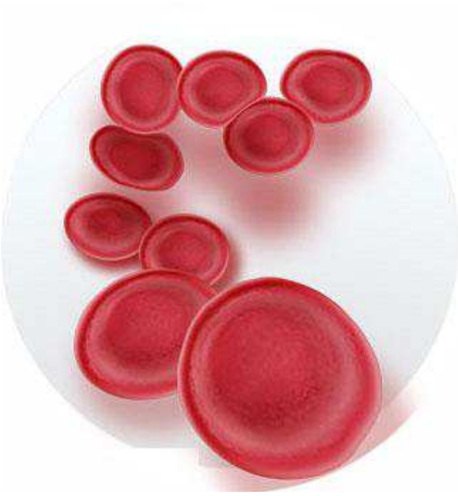

Figure 1: Red blood cell (Source: Jambhekar, 2011)

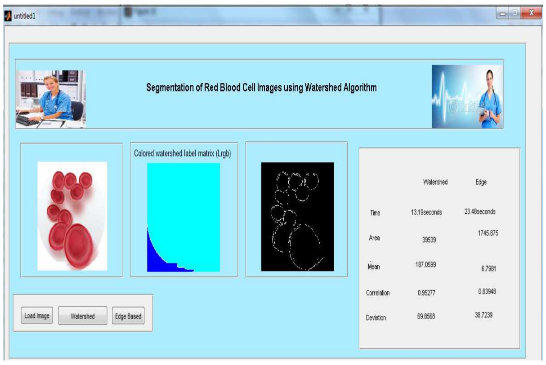

Figure 2: User

Results for watershed transformation

The corresponding results for watershed transformation of red blood cell images are shown with different plots showing distinctiveness of analysis carried out.

In figure 3, preprocessed image is applied to the image using gradient magnitude. Gradient magnitude performs gradient processing, by finding the gradient of pixels in the image, image processes uses this method during pre-processing and it identifies dark features. Gradient colour shows contrast between original colour of image and this enhances performance. In figure 4, shows opening by reconstruction of red blood cell, the images are opened by reconstructing another form of the image and this shows dark grey areas underlying in regions in the image which is a suitable for analysis.

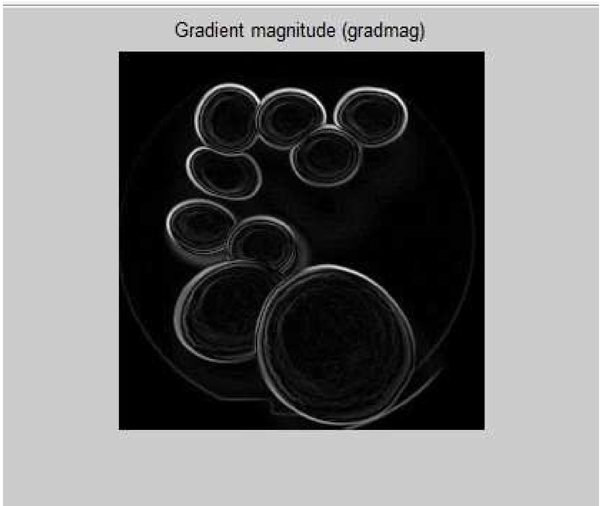

Figure 3: Processed image using gradient magnitude

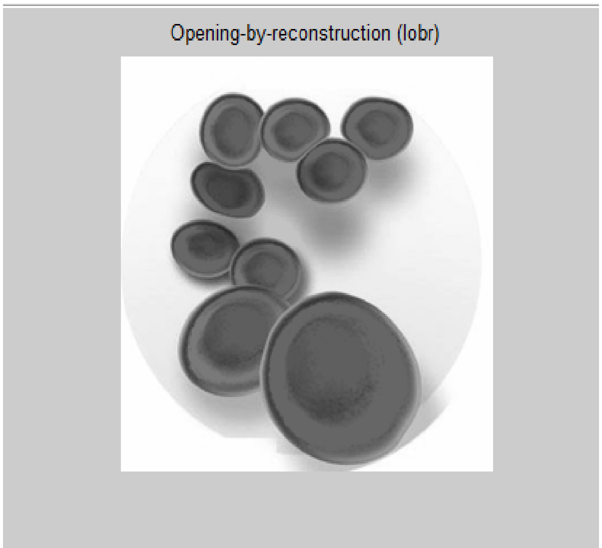

Figure 4: Opening by reconstruction

Figure 5 shows the threshold opening closing by reconstruction, the image is opened and closed by reconstruction and the resulting output is selected, the image initially opened is shown and when closed corresponding output image is observed, this is an enhancement of images**.** In figure 6, coloured watershed label matrix of red blood cell is identified, this identification is observed by the watershed label matrix in which foreground markers are identified, and then coloured markers. Lrgb stands for labelled matrix of the Red, Green, Blue (rgb) image.

In figure 7, the watershed transformed image is super imposed transparently on original image just to show the difference. Overlaying images on the transformed image shows typical differences and identification.

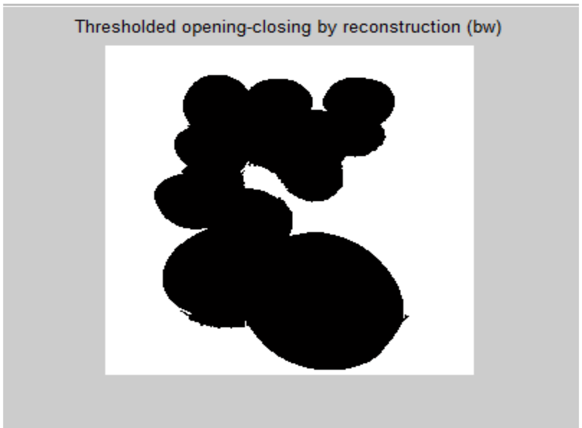

Figure 5: Threshold opening-closing by reconstruction

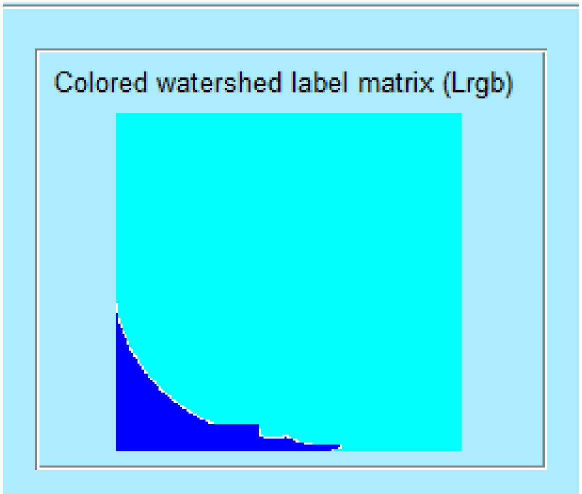

Figure 6: Colored water label matrix (rgb)

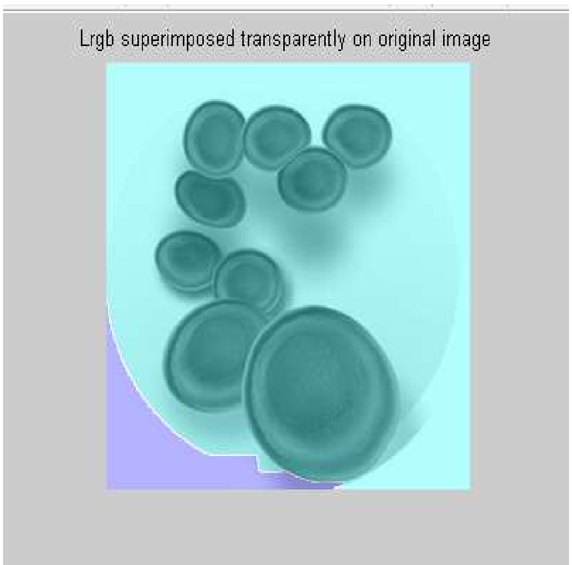

Figure 7: Lrgb superimposed transparently on original image

Results for edge based segmentation

The corresponding result gotten from segmentation analysis of edge based segmentation is shown in figure 8 and figure 9.

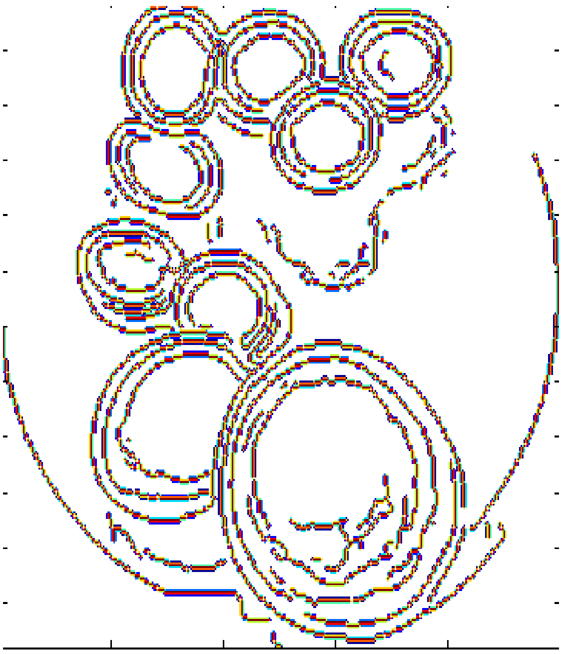

Figure 8: Edge based segmentation

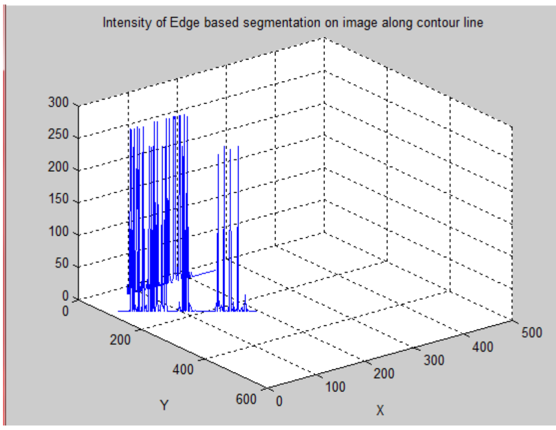

Figure 9: Intensity of edge based segmentation

Figure 8 shows the edge segmented in the images, the edges involved are useful for medical image segmentation and for identification of feasible regions which could play important roles in image analysis and segmentation. Figure 9 shows the intensity of the edge base segmentation. Image intensity is also another major factor in analyzing competence and validity of an image. The intensity values are calculated on threshold scale and analysis is performed.

Statistical results of watershed and edge based comparison

The simulation time for watershed was better than edge segmentation with a value of 73.82%, in terms of correlation, it achieved 94.99%, and deviation between pixel values was 65.85%, the area of pixel was 88.69%, finally the mean was 90.91%

Table 1: Comparison of watershed and edge segmentation

Parameters	Water Shed Transformation	Edge Based Segmentation
Simulation Time	17.84 seconds	68.57 seconds
Correlation	0.9499	0.91989
Deviation	65.846	60.317
Area	39520	4467
Mean	187.06	17.006

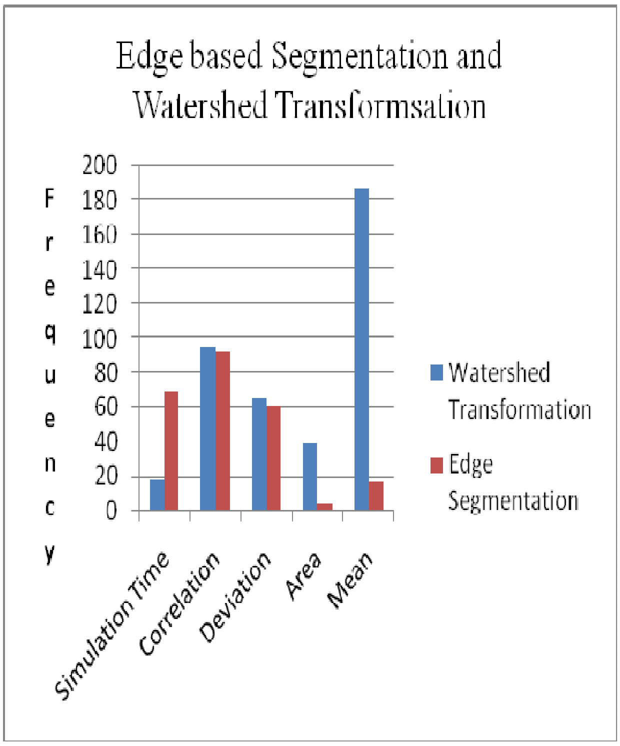

Figure 10: Comparative analysis between edge-based segmentation and watershed transformation

DISCUSSION

Simulation time is an important factor in performing simulation, the faster the simulation, the more economical the segmentation; this is because as simulation time increases, memory consumption also increases which could affects simulation results. Therefore, shorter simulation time is preferred during segmentation of images, this makes watershed transformation better.

Correlation is used to determine the absolute relationship between the binary objects in the image and the original image. The higher the correlation, the better the simulation. Watershed transformation shows a higher correlation than edge based, this makes it better than edge based segmentation.

Deviation of image is used to determine how much difference occurs between objects after image has been processed. A higher deviation is not good for image analysis, hence edge based segmentation performs more better in this aspect

The area of an image is the amount of binary objects in the image and their calculated area and connection. Both segmentations differ highly because of the difference in algorithm. Although no precise, estimation of area can be determined, but in comparison with the original image, there could be an established relationship.

The mean of an image is the average amount of interconnected pixels and objects located in the image; this is used to estimate how much contamination or particles an image has obtained during analysis. Edge based segmentation is much better in terms of mean of images because its mean value is low.

CONCLUSION

In this work, a red blood cell image was analyzed using watershed transformation, and edge based segmentation; their corresponding results were compared in which watershed transformation of the red blood cell outperformed the edge based segmentation of the red blood cell. The simulation time for watershed was better than edge segmentation with a value of 73.82%, in terms of correlation, it achieved 94.99%, and deviation between pixel values was 65.85%, the area of pixel was 88.69%, finally the mean was 90.91%. These values give valuable information, especially to physician for proper identification of information found in the image.

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