IMAGE PROCESSING BASED ABNORMAL BLOOD CELLS DETECTION

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Abstract— This paper deals with an image processing technique used for detecting the abnormalities of blood cells in less time. The proposed image processing technique also helps in counting and segregating the blood cells in different categories based on the form factor. Image processing techniques are widely used in the domain of medical sciences for detecting various diseases, infections, tumors, cell abnormalities, and various cancers. Detecting and curing a disease on time is very important in the field of medicine for protecting and saving human life. Mostly in case of high severity, diseases where the mortality rates are more, the waiting time of patients for their reports such as blood test, MRI is more. The time taken for generation of any of the test is from 2-8 days. In high risk diseases like Hepatitis B, it is recommended that the patient's waiting time should be as less as possible and the treatment should be started immediately. The current system used by the pathologists for identification of blood parameters is costly and the time involved in generation of the reports is also more sometimes leading to loss of patient's life. Also the pathological tests are expensive, which are sometimes not affordable by the patient. The proposed method gives 83% accuracy in counting the number of blood cells and 29% variation in observed values of detected abnormalities.

Index Terms— Abnormal blood cells, form factor, image processing.

I. INTRODUCTION

The blood consists of a suspension of special cells called plasma. Blood consists of 55 % plasma, and 45 % by cells called formed elements. The blood performs many important functions. By means of the hemoglobin contained in the erythrocytes, it carries oxygen to the tissues and collects the carbon dioxide (CO_2). It also conveys nutritive substances (e.g. amino acids, sugars, Mineral salts) to the tissues. Mostly in case of high severity diseases where the mortality rates are more, the waiting time of patients for their reports such as blood test, MRI is more. The time taken for generation of any of the test is from 2-8 days. In high risk diseases like Hepatitis B, it is recommended that the patient's waiting time should be

as less as possible and the treatment should be started immediately. The current system used by the pathologists for identification of blood parameters is costly and the time involved in generation of the reports is also more sometimes leading to loss of patient's life. Also the pathological tests are expensive, which are sometimes not affordable by the patient. Hence, there should be an automated system where the blood reports should be generated in a very less time with as minimum cost as possible. The proposed system would be an initiative to generate the blood test reports in minimum time and will be cost effective [1].

Currently, the time taken by pathologist is 2-8 days to generate the reports. The reports will get generated after chemical treatments on blood samples which requires more time. It is also costly and time consuming as the instruments used for identification of the blood parameters are costly. The patients suffer due to both these reasons physically as well as mentally.

In detection process several methods are used for the segmentation of red blood cell from white blood cell Using color space model with the help of MATLAB software where we can get the accuracy of up to 87%.

Various types of blood will be discussed in Section II. Section III gives a block diagram of the proposed technique. The form factor calculation used for segregating the various types of abnormal blood cells is discussed in Section IV. Section V discusses the results obtained. Concluding remarks are given in section VI.

II. TYPES OF BLOOD CELLS

There are two types of blood cells: (A) Normal blood cells and (B) Abnormal blood cells.

(A) NORMAL BLOOD CELLS

The various normal blood cells are: Enrythrocytes, Leucocytes, and Thrombocytes [2]-[8].

i) Enrythrocytes

The erythrocytes are the most numerous blood cells i.e. about 4-6 millions/mm3 They are also called red cells. In man and in all mammals, erythrocytes are devoid of a nucleus and have the shape of a biconcave lens. In the mother vertebrates (e.g. fishes, amphibians, reptilians and birds), they have a nucleus. The red cells are rich in hemoglobin, a protein able to bind in a faint manner to oxygen. Hence, these cells are responsible for providing oxygen to tissues and partly for recovering carbon dioxide produced as waste. However, most CO2 is carried by plasma, in the form of soluble carbonates.

ii) Leucocytes

Leukocytes, or white cells, are responsible for the defense of the organism. In the blood, they are much less numerous than red cells. The density of the leukocytes in the blood is 5000-7000 /mm Leukocytes divide in two categories: granulocytes and lymphoid cells or agranulocytes. The term granulocyte is due to the presence of granules in the cytoplasm of these cells. In the different types of granulocytes, the granules are different and help us to distinguish them. In fact, these granules have a different affinity towards neutral, acid or basic stains and give the cytoplasm different colors.

iii) Thrombocytes

The main function of platelets, or thrombocytes, is to stop the loss of blood from wounds (hematostasis). To this purpose, they aggregate and release factors which promote the blood coagulation. Among them, there are the serotonin which reduces the diameter of lessoned vessels and slows down the hematic flux, the fibrin which trap cells and forms the clotting. Even if platelets appear roundish in shape, they are not real cells. In the smears stained by Giemsa, they have an intense purple color.

(B) ABNORMAL BLOOD CELLS

The various abnormal blood cells are: Elliptocyte, Echinocyte, Dacrocyte, and Sickle cells [2]-[8].

i) Elliptocyte

Elliptocytes are red blood cells that are oval or cigar shaped as can be seen from Fig. 1. They may be found in various anemias, but are found in large amounts in hereditary elliptocytosis.
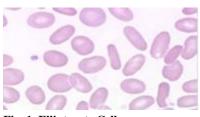

Fig. 1. Elliptocyte Cells

ii) Echinocyte (Crenated Red Blood Cells)

Echinocytes shown in Fig. 2 are red blood cells with many blunt spicules, resulting from faulty drying of the blood smear or from exposure to hyperosmotic solutions. Pathological forms are associated with uremia. Echinocytes contain adequate hemoglobin and the spiny knobs are regularly dispersed over the cell surface, unlike those of acanthocytes.
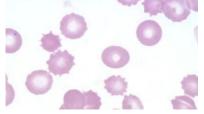

Fig. 2. Echinocyte Cells

iii) Dacrocyte (Tear Drop Cells)

Teardrop shaped red blood cells are found in myelofibrosis and other myeloproliferative disorders, pernicious anemia, thalassemia, myeloid metaplasia, and some hemolytic anemias. Fig. 3 shows a typical shapes of dacrocyte cells.
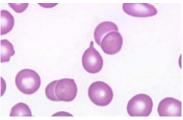

Fig. 3. Dacrocyte Cells

iv) Sickle Cells

Sickle cells shown in Fig. 4 are red blood cells that have become crescent shaped. When a person with sickle cell anemia is exposed to dehydration, infection, or low oxygen supply, their fragile red blood cells form liquid crystals and assume a crescent shape causing red cell destruction and thickening of the blood. Since the life span of the red blood cell is shortened.

Fig. 4. Sickle Cells

The paper aims to detect the abnormal blood cells by image processing technique. Here, the abnormality off the blood cells will be detected by determining the form factor of the cells. The form factor will be calculated by calculating the area and perimeter of the cells with the help of edge detection algorithm and finally the number of abnormal blood cells will be

counted. The proposed technique will help in reducing the cost as well as waiting time of the patients for availing the pathological reports.

III. BASIC BLOCK DIAGRAM [3]

The system will be working as follows:- Once the patient's blood sample is collected, it will be processed immediately and using an high end camera's in microscope, the images can be captured and using the image processing techniques, the different values of the desired parameters can be calculated immediately [1]. Use of parameter dependent image processing technique will definitely reduce the cost involved and also will save the time of generating the reports. This will definitely help to reduce the mortality rate in high risk diseases [2]. Fig. 5 shows the basic block diagram for detecting the abnormal blood cells.

i) IMAGE ACQUISITION

The digital microscope is interfaced to a computer and the microscopic images are obtained as digital images. The resolution of the digital image depends on the type of digital microscope used

ii) IMAGE ENHANCEMENT:

For better segmentation of the blood cells, the imported image has to be enhanced. This improves the quality of the image in terms of details.

(a) Green Plane Extraction:
The green plane is extracted from the imported blood cell image. The other planes such as red and blue are not considered because they contain less information about the image.

(b) Contrast Adjustment:
To enhance the image, its contrast is adjusted by altering its histogram. The image's histogram is equalized.

iii) IMAGE SEGMENTATION

This involves selecting only the area of interest in the image. Here only the blood cells are selected, because they are the areas of interest A segmentation can be used for object recognition, occlusion boundary estimation within motion or stereo systems, image compression, image editing o image database look up.
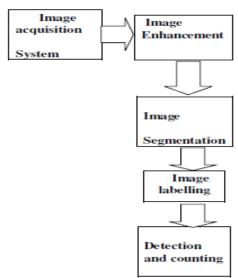

Fig. 5: Block diagram for detecting abnormal blood cells.

IV. DETECTION AND COUNTING OF ABNORMAL BLOOD CELLS USING FORM FACTOR CALCULATION [4]

Form factor threshold is fixed for different abnormal cells. All the cells having the form factor value less than 0.6 are considered abnormal and the cells having the form factor range between 0.6-1 are considered as normal cells. Based on these criteria the abnormal cells are detected. The flow chart for detection and counting the blood cells is given in Fig. 6. By incrementing a counter value within for loop, the number of normal cells and abnormal cells can be calculated. Form factor is calculated for the labelled cells. So the basic aim is to calculate the area and perimeter [9], [10].

Calculation of an area:

Number of pixels in one cell makes its area. So the number of pixels having same label constitute the area of the labelled cells.

Calculation of the perimeter:

Any pixel whose four neighborhoods are white is surely not a boundary pixel as it lies interior of the cell. So we get number of those pixels whose four of the neighborhoods are white. And if we subtract this value from the total area of the Image then this will give area outside the cell along the perimeter of the cell. Hence the form factor can be calculated easily using eqn. (1).

$$\text{Form factor} = 4 * pi * area / (perimeter * perimeter) \qquad (1)$$

This form factor varies as the shape of an object varies. For a perfect circle, the form factor value is equal to 1, for objects other than circle, this form factor varies. The form factor ranges for different abnormal cells
Acanthocyte: 0.31-0.5
Echinocyte: 0.7-0.8
Elliptocyte: 0.6-0.7
Dacrocyte: 0.4-0.6
Sickle cell: less than 0.5

Nucleated erytrocyte: 0.6-0.65.
Based on this criteria, different objects in an image can be detected and classified.

The Steps involved in the algorithm are explained below:
- Read Image
- Get the x and y corner coordinates as integers
- Index into the original image to create the new image
- Extract the cytoplasms
- Solidifying the cytoplasms
- Use the Gradient Magnitude as the Segmentation Function
- Use the Sobel edge masks, |imfilter|, and some simple arithmetic to compute the gradient magnitude. The gradient is high at the borders of the objects and low (mostly) inside the objects.
- Mark the Foreground Objects
- A variety of procedures could be applied here to find the foreground markers, which must be connected blobs of pixels inside each of the foreground objects. In this example you'll use morphological techniques called "opening-by-reconstruction"and"closing-by-reconstruction " to "clean" up the image. These operations will create flat maxima inside each object that can be located using |imregionalmax|.

- Opening is erosion followed by a dilation, while opening-by-reconstruction is an erosion followed by a morphological reconstruction. Let's compare the two. First, compute the opening using |imopen|.
- Compute the opening-by-reconstruction using |imerode| and |imreconstruct|.

Following the opening with a closing can remove the dark spots and stem marks. Compare a regular morphological closing with a closing-by-reconstruction. First try |imclose|. Now use |imdilate| followed by |imreconstruct|. Notice you must complement the image inputs and output of |imreconstruct|.
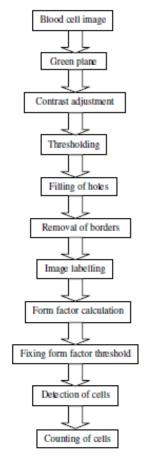
Detection of cells:

Fig. 6: Flowchart for detection of abnormal

- As can seen by comparing |Iobrcbr| with |Ioc|, reconstruction-based opening and closing are more effective than standard opening and closing at removing small blemishes without affecting the overall shapes of the objects. Calculate the regional maxima of |Iobrcbr| to obtain good foreground markers.

- To help interpret the result, superimpose the foreground marker image on the original image.
- Notice that some of the mostly-occluded and shadowed objects are not marked, which means that these objects will not be segmented properly in the end result. Also, the foreground markers in some objects go right up to the objects' edge. That means you should clean the edges of the marker blobs and then shrink them a bit. You can do this by a closing followed by erosion.

- This procedure tends to leave some stray isolated pixels that must be removed. You can do this using "bwareaopen", which removes all blobs that have less than a certain number of pixels.

- Compute Background Markers. Now you need to mark the background. In the cleaned-up image, |Iobrcbr|, the dark pixels belong to the background, so you could start with a thresholding operation.
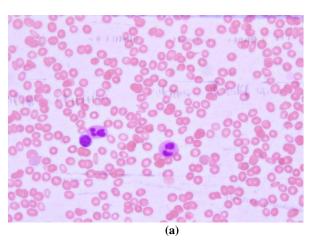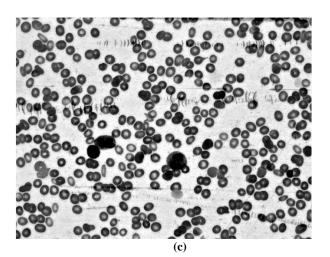
- The background pixels are in black, but ideally we don't want the background markers to be too close to the edges of the objects we are trying to segment. We'll "thin" the background by computing the "skeleton by influence zones", or SKIZ, of the foreground of |bw|. This can be done by computing the watershed transform of the distance transform of |bw|, and then looking for the watershed ridge lines (|DL == % 0|) of the result.

- Compute the Watershed Transform of the Segmentation Function. The function |imimposemin| can be used to modify an image so that it has regional minima only in certain desired locations. Here you can use |imimposemin| to modify the gradient magnitude image so that its only regional minima occur at foreground and background marker pixels.

- Finally compute the watershed-based segmentation.

- Visualize the Result: One visualization technique is to superimpose the foreground markers, background markers, and segmented object boundaries on the original image. You can use dilation as needed to make certain aspects, such as the object boundaries, more visible. Object boundaries are located where |L == 0|. This visualization illustrates how the locations of the foreground and background markers affect the result. In a couple of locations, partially occluded darker objects were merged with their brighter neighbor objects because the occluded objects did not have foreground markers.

- Another useful visualization technique is to display the label matrix as a color image. Label matrices, such as those produced by |watershed| and |bwlabel|, can be converted to truecolor images for visualization purposes by using |label2rgb|. One can use transparency to superimpose this pseudo-color label matrix on top of the original intensity image.

- Separate all solo-connected shapes.

- Calculate form factor F.

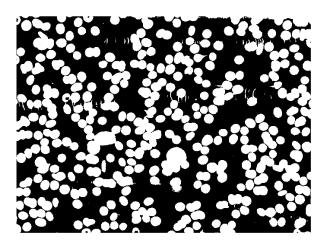## V. RESULTS AND DISCUSSION

The proposed algorithm is tested on the blood cell images as shown in Fig. 7. The total number of blood cells present in the image is counted using proposed algorithm (implemented using MATLAB). The algorithm shows the form factor for the blood cells which are more or less in circular shapes is in the range of .8 to 1 and that for others in the range of 0.4 to 0.6. Also, the total number of cells is estimated and it matches with the actual count.
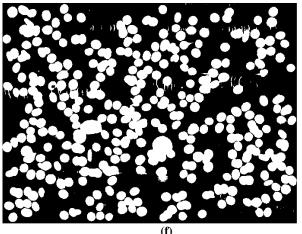

(a)

(b)

(c)

(d)

(e)

(f)

Fig. 7: (a) Blood cell images (b) Gray scale image (c) contrast adjustment (d) Binary image (e) Holes filled in the image (f) Clearing the borders in the image

For testing purpose the image shown in Fig. 8 was taken.

Fig. 8: Blood cell image for testing purpose

In the cell image we have total 12 cells. Where 10 cells are normal and 1 cell is abnormal. Calculated form factor is as follows: 1.05, 1.04, 0.90, 1.12, 1.00, 0.98, 0.96, 0.94, 0.40, and 1.05.

So here range of form factor is in between 0.94 to 1.12. So there are the normal cells. But the cell which have a value of form factor is less than 0.8 is considered as an abnormal cell. Here the only one cell which has a value is 0.40, considered as abnormal blood cell. The statistical analysis is given in Table I. The R^2 value indicates there is 29% variation in observed values.

Table I: Statistical analysis of the blood cells shown in Fig. 8.

	Number of Cells	Form Factor	Remark(s)
Total Cells:	12		
Detected Cells:	10		
Normal Blood Cells:	09	Between 0.94 to 1.12	
Abnormal Blood Cells:	01	0.4	Acanthocyte cell
Variance of Observed Response			0.06416
Sum of Squares of Errors (SSE)			0.5775
Total Sum of Squares (SST)			0.81913
Coefficient of Determination (R^2)			0.29498

VI. CONCLUSIONS

The paper proposes an image processing technique for detecting and counting the abnormal blood cells. The proposed method detects the abnormalities in blood cell in very less time and efficiently. The 83% accuracy is achieved in counting the number of blood cells and 29% variation in observed values of detected abnormalities. The abnormalities of the blood cells are getting segregated based on form factors.

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