

Review on Identification of Red Blood Cells by Image Processing

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Abstract— Analysis of blood smear is an important diagnostic test used in the diagnosis of an array of diseases. The method of automatic diagnosis of microscopic blood smear images by identifying and separating it to different categories of cells that are highlighted in the paper. Automation of this process ultimately narrows the scope of possible diseases saving a considerable amount of time. Identification of red blood cells (RBCs) is carried out/done by the system using different techniques of image processing operations like pre-processing, operations for morphology, labelling and extraction of features to calculate shape and size of the RBCs. Morphological properties can provide information regarding shape of the cell. By these operations and calculations, RBCs are classified. There are 2 stages in red cell classification process, first is the separation of RBCs to normal and abnormal followed by abnormal cells classification to three subclasses based on the cell shape and structure. The aim of this system is to assist pathologist by giving quick results by analysing the smear samples. The cure of these diseases is possible, when it is detected at an earlier stage.

Keywords—RBC count, RBC Classification, Shape and size of RBC, Image Processing.

I. INTRODUCTION

The main part of the immune system of human body is formed by RBC also termed as erythrocytes. Haemoglobin is a biomolecule contained in blood, which provides red color to it. Lack of normal RBC in the body results in lack of oxygen. Morphological changes are observed in mature red cells, during the disease. [1]. Risk factors: Some of the risk factors may include-Family history, Chemical exposes, Cancer treatment, Radiation, Congenital syndrome such as down syndrome.[2]

The main components of blood are RBCs, White Blood Cells (WBCs), Platelets and Plasma. Based on texture, color, size, and morphology of nucleus and cytoplasm, the cell can be differentiated. Person with the disease, has abnormal count of cells and needs medical help.[3]

The blood analysis is done by making a thin film of blood spread equally on a glass slide for pathologists to study under a microscope, is known as a blood smear. In our body, abundant RBCs or erythrocytes are present due to which our blood is red. Oxygen is delivered to various parts of our body by these RBCs.[4]

In order to obtain the RBCs from the sample, it must be separated from the WBCs. WBC is obtained using KMedoids

algorithm. Separation is done using granulometric analysis. for feature extraction, the output of separated image containing only RBCs is given as input. Geometric factors are calculated, based on which system is developed to separate the disorder to different categories based on the compared results of defined value and deviation from the defined factor values. [1]

Extracting features that result in some quantitative information of features of interest that are used as basics for differentiating one class of objects from another is termed as feature extraction. Geometrical feature extraction and textural feature extraction are the two types of extraction. In this paper, we are more concerned about the Geometrical features of RBCs based on which factors are calculated for a single RBC. [5]

Area and perimeter are computed using Form Factor for each cell which is used for detection of the abnormal RBC. In the paper, the work involves various steps for the detecting abnormal RBC. The steps involved in detection are Image Acquisition, Image Segmentation, Detection of Abnormal RBC and Detecting the Type of Abnormal RBC. [6]

In the analysis of medical images, techniques of digital image processing are important which includes image enhancement, image filtering, segmentation, image masking, edge detection etc. Contrast stretching, unsharp masking, edge detection etc. are a part of image enhancement. Removing noise from an image is carried out by image filtering. Subdividing an image into its constituent parts is known as segmentation. Segmentation includes region growing, splitting and merging and thresholding etc. Image enhancement methods are adapted to emphasize certain features and to remove artifacts. [5]

Pre-processing:

Pre-processing includes various steps like-

A) *Binarization* [7]

The method of converting black – white image from any grayscale image. Binarization process starts by finding the threshold value for grayscale image and check the intensity of gray value from the pixel image. If value of pixel > the threshold, then the pixels is white, else the pixel is black when pixel < threshold.

B) Image Enhancement [8]

Here, the image is made glaring, by the use of the available color on the screen or output device. In order to increase the contrast of the image, range of values for the image is manipulated.

C) Morphological Operations [8]

Morphology operations, process images based on shapes with a range of image processing operations. Operations are carried out by ensuring the size input image is same size as output image, these are done by Dilation and erosion which are a part of morphological operations. Addition of pixels is dilation and removal of pixel is erosion.

1. Erosion [9]

This operation removes pixels on object boundaries. In a binary image, a pixel is set to 0 if any of the neighboring pixels having value 0 Morphological erosion removes islands and small objects so that only substantive objects remain.

2. Dilation [10]

Addition of pixels to the image object boundaries. In a binary image, a pixel is set to 1 if any of the neighboring pixels having value 1, this operation makes objects more visible and fills in small holes present in the objects.

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II. RELATED WORK

Methods:

A system with rules to classify the cells is developed. The number of cells falling under each category is computed to find the abnormal cells.[1]

Actual number of pixels in the region is given by area, Distance around the boundary of the area is given by perimeter.

And the ratio between the Area and perimeter is termed as diameter.

$$Diameter = \frac{Area}{4 * Perimeter}$$

Shape Geometric Feature (SGF): The RBCs are usually oval in shape.

$$SGF = \frac{Large Diameter}{Small Diameter}$$

Area Proportion: It is the ratio between the central pallor area to the cell area.

$$Area Proportion = \frac{Central Pallor Area}{Cell Area}$$

Deviation: It is the ratio between the shape geometric factor and area of the object.

$$Deviation = \frac{SGF}{Cell Area}$$

Central pallor: This feature suggests if the cell has a central pallor or not. It is set to one if it exists or else it is set to zero.

Form Factor: It is a measure of irregularity. It is given as the ratio between Area and perimeter.

$$Form Factor = \frac{4 * \pi * Area}{Perimeter^2}$$

A low-cost disease diagnosis method is implemented that uses RBC & WBC cell structure. Cell structure determination is done by Hough transform algorithm, whose purpose is to find imperfect shape of RBCs with in the smear sample. Hough transform has been extended find the arbitrary shapes, mostly circles or ellipses. In this paper, they have used Sobel algorithm for segmentation, background is separated from the object. K- means clustering is used for data base comparisons [3].

Image Processing is the technology of enhancing the quality of the image or to extract information from the image digitally, using computer algorithms. Here, input is an image and the output of image processing can either be an image or some parameters of the image. This process includes many steps, greyscale conversion, noise removal, image conversion to Binary, filling the holes of these cells and clean incomplete cell and cells at the boundary, followed by removal of WBCs and platelets. Obtaining only RBCs for conversion and classification [4].

To separate RBCs from other components,

$$T = RBC + WBC + PLATELET COUNT$$

$$U = RBC + WBC COUNT$$

$$NO. OF WBC'S = V$$

$$NO. OF RBC'S = U - V$$

$$NO. OF PLATELETS = T - (U + V)$$

After pre-processing, filters are used to remove the noise from the image as to get a better image. Here, for noise removal they have used median filtering. Then is the segmentation of image. The sickle cell affected blood smear image consists of normal RBCs, abnormal RBCs, sickled RBCs etc. The main problems of sickle celled RBCs is that

they cling together and block the blood vessels. Otsu's method and Watershed segmentation method are used for segmentation purpose. Watershed segmentation gives better segmentation result in segmentation [5].

Form factor gives the classification as normal cell, abnormal cell. compactness gives shape of the cell.

$$\text{Form factor} = 4 * \pi * \text{area} / \text{perimeter}$$

$$\text{Compactness} = \text{Perimeter} / \text{Area}$$

Segmentation the blood smear images uses MATLAB. 1000 blood smear images were experimented on to get accurate results. Their work aims to separate components of blood. Followed by feature extraction.

This system has various steps involved to detect the abnormal RBCs. The steps are image acquisition, image pre-processing, image segmentation, image post processing, detection of abnormal RBC and its type. Values of calculated Fourier transform values is compared with the values of database System giving the result about the normality of RBC followed by classification of the type of abnormal RBC [6].

2D area or boundary is represented using 1D function in case of signature method. We find the g_x, g_y using the Centroid distance

$$G_x = \left| \sum_{i=0}^{i=N-1} \frac{(x_i + x_{i+1}) * (x_i y_{i+1} - x_{i+1} y_i)}{6A} \right|$$

$$G_y = \left| \sum_{i=0}^{i=N-1} \frac{(y_i + y_{i+1}) * (x_i y_{i+1} - x_{i+1} y_i)}{6A} \right|$$

Where, A is given by,

$$A = 0.5 \left| \sum_{i=0}^{i=N-1} (x_i y_{i+1} - x_{i+1} y_i) \right|$$

Distance of the boundary points from the centroid (g_x, g_y) of a shape r:

$$r(t) = \sqrt{((x(t) - g_x)^2 + (y(t) - g_y)^2)}$$

Fourier Transform of r(t):

$$A_n = \sum_{t=0}^{t=N-1} \frac{r(t) * e^{\left(\frac{-j2\pi nt}{N}\right)}}{N}$$

For $n = 0, 1, 2, 3, \dots, N-1$

In [11], paper suggests involvement of various processes like pre-processing, feature extraction, factor calculation.

Image Processing

In the proposed method, the first step is to pre-processing the images, which is an essential step of pre-processing. RGB images of the sample is converted to grayscale images. These grayscale images are enhanced and converted to binary images. From the resulting images, half-cells, border cells are removed. Cells in the clean image are labelled. For each labelled cell, features are extracted by factor calculation (fig-2).

Feature Extraction

- Area
- Diameter [1]
- **Major Axis** represents the measure of the major axis of the ellipse
- **Minor axis** represents the measure of the minor axis of the ellipse

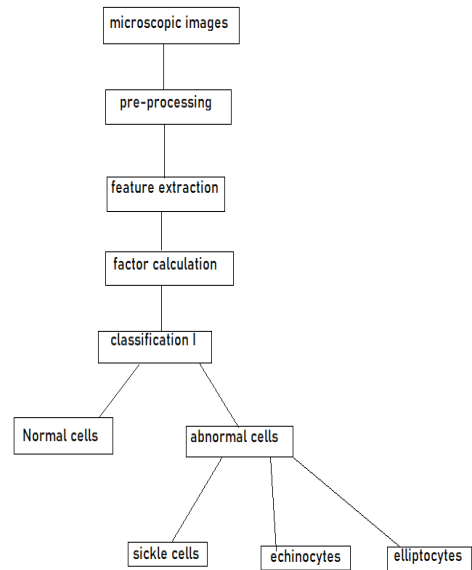


Fig.1. RBC Classification

Factor Calculation

- **Circularity factor (CF):** If $CF < 1.2$, then cells are normal, else elongated.

$$CF = \frac{\text{Major Axis}}{\text{Minor Axis}}$$

- **Formfactor (FF):** if cells are normal, then $FF = 1$, else the cells are abnormal

- **Deviation Factor (DF):** If the cell has no variation in shape, $DF < 0.2$, else the cell shape has abnormalities.

$$DF = \frac{CF}{Area}$$

- **Semilunarity Factor (SF):** Factor that is exclusively used to detect sickle cells. If $SF < 1.78$, then the cell is said to be sickle cell.

$$SF = \frac{\text{Major Axis}}{\text{Major Axis} - \text{Minor Axis}}$$

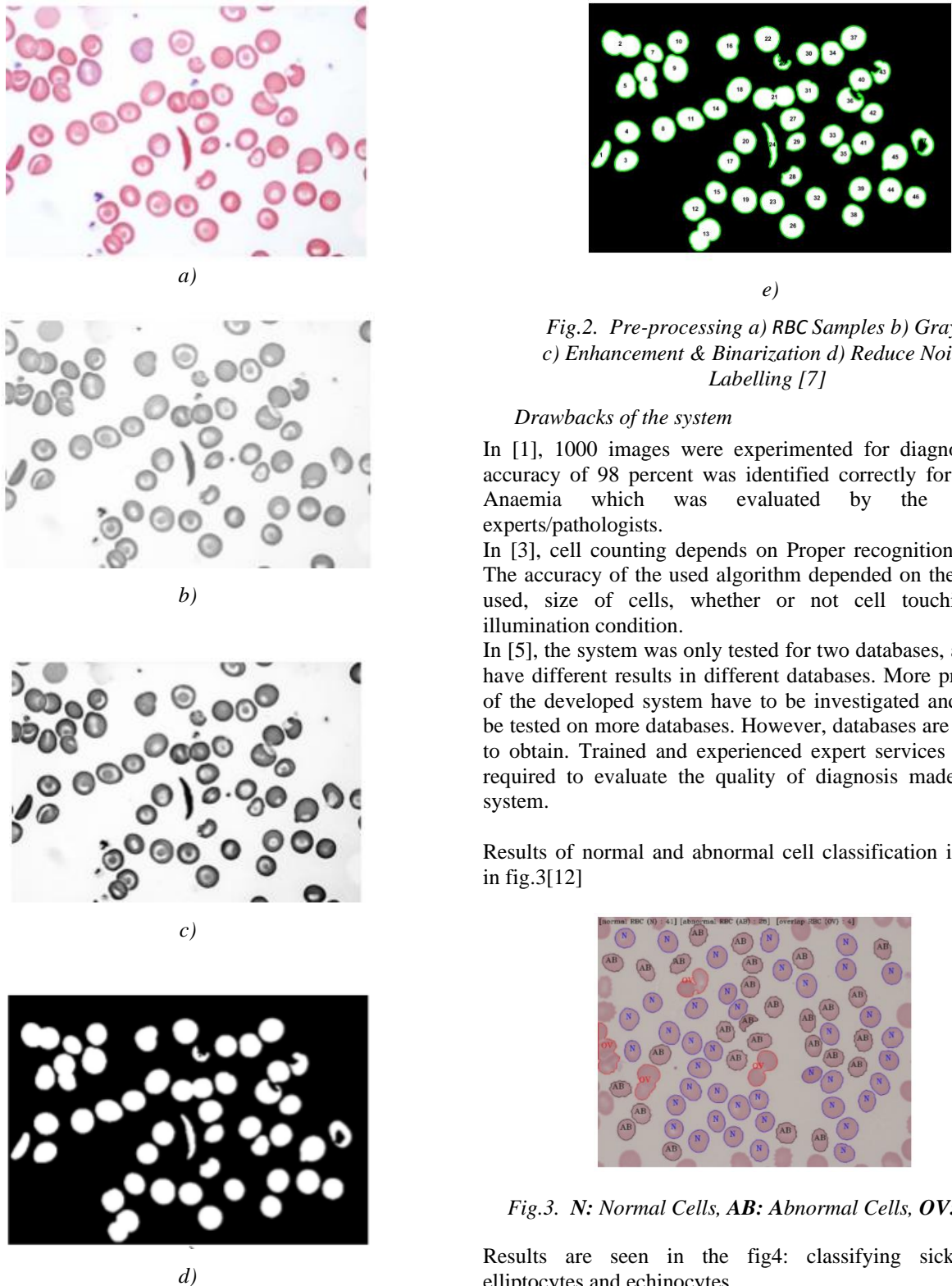


Fig.2. Pre-processing a) RBC Samples b) Grayscale c) Enhancement & Binarization d) Reduce Noise e) Labelling [7]

Drawbacks of the system

In [1], 1000 images were experimented for diagnosis. An accuracy of 98 percent was identified correctly for type of Anaemia which was evaluated by the medical experts/pathologists.

In [3], cell counting depends on Proper recognition of cell. The accuracy of the used algorithm depended on the camera used, size of cells, whether or not cell touching and illumination condition.

In [5], the system was only tested for two databases, and may have different results in different databases. More properties of the developed system have to be investigated and should be tested on more databases. However, databases are difficult to obtain. Trained and experienced expert services are also required to evaluate the quality of diagnosis made by the system.

Results of normal and abnormal cell classification is shown in fig.3[12]

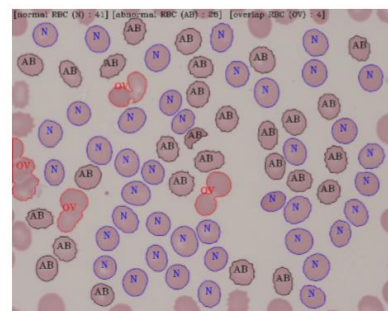


Fig.3. *N: Normal Cells, AB: Abnormal Cells, OV: Overlap*

Results are seen in the fig4: classifying sickle cell, elliptocytes and echinocytes.

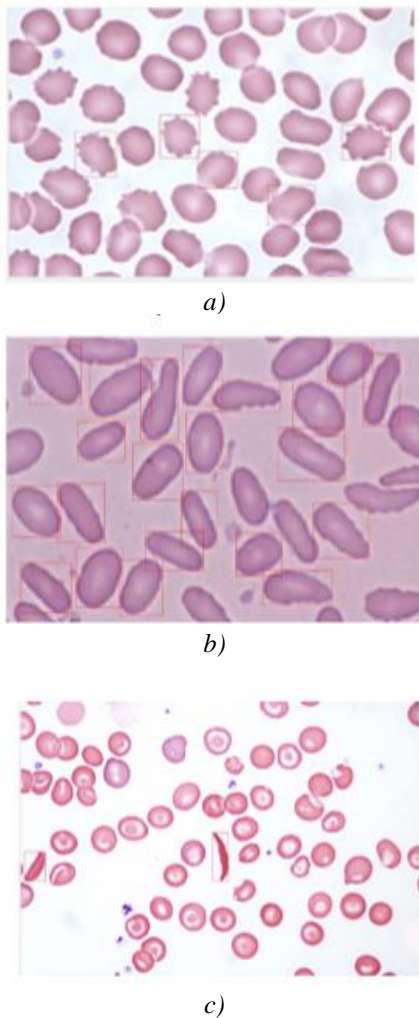


Fig.4. Types of Cells Detected: a) Echinocytes
b) Elliptocyte c) Sickle Cell

CONCLUSION

Disease diagnosis by computer algorithm (image processing) is getting more popular today due to its continuous operations that are fast, reliable and accurate in diagnosis of the disease. The process by which a disease can be found based on the symptoms and results of various tests conducted on the person is known as diagnosis. In this paper there are many

techniques of image processing from which RBCs are separated based on shape and size of the cells. Research work in this field are growing with every passing day and many techniques are used to get more accurate result.

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