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RBC Classification in Blood Smear Image using Neural Network

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Abstract*: Biomedical image processing becomes an emerging field due to automation in the field of medical science with the help of image processing techniques. In medical science it is very much essential to diagnosis a disease accurately and efficiently. Most of the disease which deals with the blood test report for diagnosis of the disease. This paper proposed a computer vision based method which extract the Red Blood Cells (RBC) from a blood smear image and classify it whether normal or abnormal. Then it will count the normal RBC as well as abnormal RBC. This method works in two parts, one is segmentation of blood cell and other is classification and counting of segmented blood cells using neural network. The Neural network trained and classified using shape and moment invariant features because this features are invariant to translation, scaling and rotation. The proposed method performs well and gives about 90 percent of correct result.

Keywords: Biomedical, Neural Network, Morphology, RBC

I. INTRODUCTION

Biomedical image processing becomes most research area in present scenario. Due to vital role in the field of medical science, the biomedical image processing becomes most evolving research area among the researchers. So in recent years there is a increase in interest on development of algorithm which include image processing and medical science [1-2]. Most of the diseases can be diagnosis through blood test report. So for better diagnosis proper method has to be used. Mostly numerous blood cells in the human body, and it also called red blood cells. The function of red blood is to carry oxygen through the body. The Counting of red blood cells in a blood sample can give the pathologists valuable information regarding hematological information. Researchers are developing many automatic diagnosis system which help doctors to diagnose disease in red blood (RBC) and white blood (WBC) cells [3]. The conventional methods include the man power which is less reliable also less efficiency.

Accurate diagnosis is very much essential in medical science. So it needs to develop some image processing technique which automatically counts RBC. The counting of RBC requires 3 steps, start with segmentation, feature extraction and classification [4-5]. Out of the three steps the first segmentation method is the important one because the rest process feature extraction and classification depends on the segmentation method. And the segmentation method is very challenging as it has to be done on microscopic image [1]. Researchers have developed different segmentation methods, but the weakness in those methods leads to problem during correction process. During segmentation process it is necessary to perform correctly because RBC, WBC and background all are very close to each other. This basically need correct clustering of pixels.

To extract the feature of RBC, morphological operations such as dilation and erosion have applied. Dilation adds pixels to the boundary of object in the image where as erosion removes the pixels of boundary [6-8]. The mathematical morphological operators used to segment RBC by eliminating WBC appearance [9]. The morphological operators used for extracting the image components which are useful in representation and description of region of shape like boundary, skeleton and texture etc. [10-11].

II. NEURAL NETWORK

Neural network based on concept of biological neural system. The system is a distributed information processing system consists of same type of simple processing unit arranged in a manner [12]. The best part of this network is that is adaptive in nature which adapt the system through a learning process. The system train though a pattern of input and adapt itself to give output based on the training. The characteristic of neural network is determined by the type of learning methods [13]. The hidden layers then link to an 'output layer' where the answer is output as in figure. The output is controlled by an activation function [14]

Neural network consists of number of layers called as input layer, hidden layers and output layer. Each layer contains inter connected nodes. The hidden layer can be of multiple numbers. The patters are provided to input layers, it process the input through hidden layer to output layer through an activation function. The inter connection between nodes of layers through weighted vectors. The hidden layers then link to an 'output layer' where the answer is output as in figure. The output is controlled by an activation function [15]

A. Activation Function

The activation function gives the final output. Out of different activation function the sigmoid function most widely used, because other activation function add nonlinearity to the network

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1. Sigmoid Function: The Sigmoid function is a continuous version of the Ramp function and provides a graded nonlinear response within a specified range The most common sigmoid function is the Logistic distribution function that provides an output value from 0 to 1.The value $\alpha > 0$ and usually equal to 1

The Sigmoid function definition is shown at Equation

$$f(x) = \frac{1}{1+e^{-x}} \qquad (1)$$

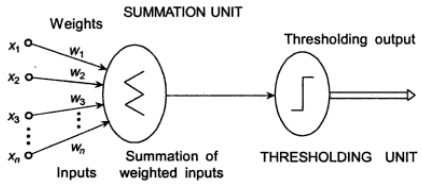

Fig. 1 A simple Neural Network

B. Single Layer Neural Network

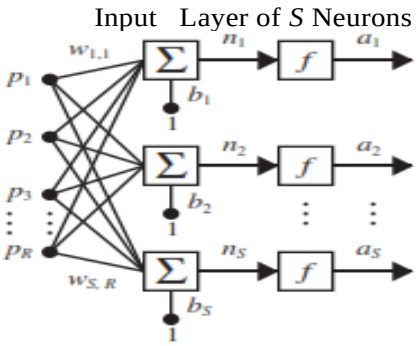

Fig.2. Single Layer Neuron Network

The network below shown in figure 2 is a single layer network, where R numbers of input is connected to each of the neuron and the weight matrix has S rows

In the given network each of input vector p is connected through the weight matrix W, each of the neuron associated with a transfer function, a summer, an output a_i through a bias b_i.

III. IMPLEMENTED METHODOLOGY

The proposed method for detection and classification of RBC is outlined in the below flow diagram.

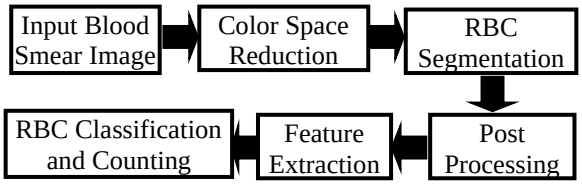

Fig.3. Proposed Methodology

A. Input Blood Smear Image & Color space Reduction

A computer based system is proposed for automatic detection and identification of RBC from blood smear image. It detect, classify and counting normal and abnormal red blood cell (RBC) in blood smear image. The proposed method operates on input blood smear image which are collected from a laboratory. The main motive is to extract the bloods cell from the background, which can be done better with the green channel of the color image. So we need to extract the green component from the color image.

B. RBC Segmentation

The image segmentation process is mainly implemented to partition an image into a region of homogenous representation corresponds to the object of interest. For this region we have implemented a method called Otsu thresholding method [16], which has applied to the green channel to separate blood cells and background.

C. Post Processing

After segmentation still there is some noise, holes and cell in border exist. To overcome this, a set of post processing method is applied. For post processing we have used three methods which are morphological operation, connected component labeling (CCL) and bounding box filter to remove the unnecessary items.

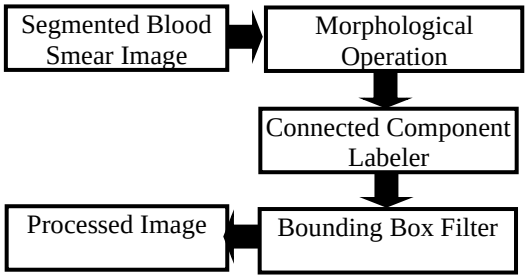

Fig.4.Post Processing

Morphological operation works on binary image to change the size, shape, structure and connectivity of objects by using a structuring element and a set operator which are Erosion and Dilation [17]. Both erosion and dilation use a structuring element for increasing and decreasing the shape of an object. Erosion shrinks the object where as dilation expand or grows the objet. Both the operator usd to remove or break connection, clearing of boarder or filing the hole.

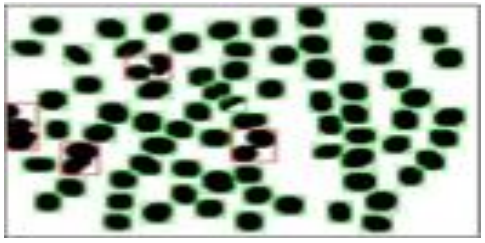

Fig. 5.Post Processing Operation

D. Feature Extraction

For classification or extraction, it is very much essential to characterize the blood cell in terms of certain parameter. So for that it needs to extract certain parameter of the cells which can be called as features. As the red blood cell are somehow circular in nature, so the geometrical features like compactness and moment invariant should extracted. Compactness is a common shape measurement technique based on the information from the perimeter (L) and area (A). Moment method has been used in the analysis and recognition of object shape [17].

Fig. 6. Morphological Feature Extraction

C. RBC Classification & Counting

In order to be able to differentiate between normal and abnormal RBC in the image by using the selected features, a robust classifier should be used. We have used an artificial neural network (ANN) as a classifier.

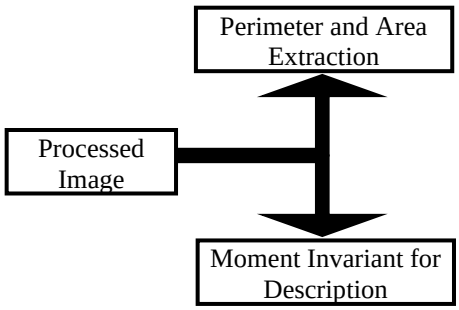

Fig. 7 Feature Extraction Methods

D. Feature Extraction and Classification

1. Moment Invariant for Description: Moment invariants have been frequently used as features for image processing, shape recognition and classification. After segmentation operation the moment of image uses to describe the object through its shape. Moment mostly used in image analysis to derive the invariants. Moment invariant features which derived from moment used for object representation and recognition. Numbers of techniques have been developed to derive moment invariant features. The advantage of this feature is that these features are invariant to translation, scaling and rotation of any shape. Moment invariant is widely used method for classification through a particular type of shape.

By using the selected features, a robust classifier should be used. The classification module is performed by using artificial neural network (ANN) classifier. The ANNs are a mathematical approximation of a biological brain, and have been identified as a useful framework for precise modeling of nonlinear response. It comprises a number of neurons connected together to form a network.

Fig. 8. Flow Diagram of ANN

IV. RESULTS & DISCUSSIONS

The proposed method leads to Identification of normal and abnormal blood cell that will classify the both type blood cell. After classification of RBC, it again undergone for counting of normal and abnormal cell to have the total RBC Count as desired by the proposed method.

The experimental simulation has been done using MATLAB 8.3 (R2014a). First of all data set of different blood cell has been created, which are collected from pathology lab. As per system requirement it first needs to train the Artificial Neural Network for its performance. Towards training purpose 50 test data sets has been collected out of which 30 have been used for training and rest all are used for validation.

In the proposed method 8 hidden nodes and sigmoid type activation function has used. During training session the system has tested using different number of hidden nodes starting from 2 to 10. When the hidden nodes were increasing the computational complexity was increases as well as the accuracy slightly decreases. Also the ANN system using tangent type activation function, but the system best work with 8 number of hidden node with a sigmoid type activation function. After training session bloods sample smear images have tested for classification and counting of RBC.

In the first section RGB blood sample smear image (microscopic view) was taken, that were explorer to have it Red, Green and Blue channel. Out of which the green channel has selected for further processing. The result given below for two set of sample test image as shown below.

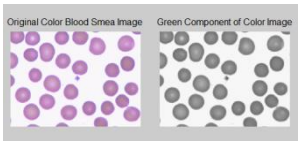

Fig.9. Original and Green Component Image of Normal RBC

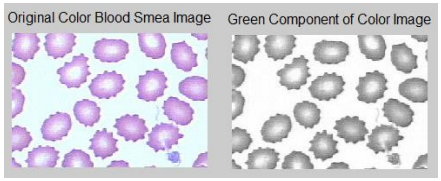

Fig.10. Original and Green Component Image of Abnormal RBC

Because the green channel is more convenient for segmentation and extraction of blood cell, the green channel has selected only. After that for the segmentation Ostu method [16] has applied for segmentation of blood cell. The segmentation result shown below after applying Ostu method.

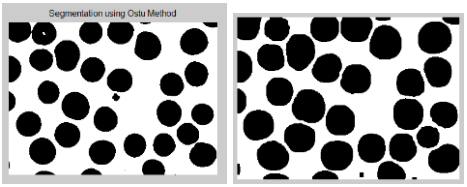

Fig. 11. Segmented Result after Ostu method

After segmentation for proper cell extraction some preprocessing based on morphological operation which implemented by erosion operation has been done. The post processed image shown below.

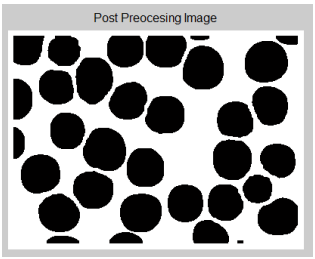

Fig.12. Preprocessed Image after Segmentation

As the system need to extract the RBC cell, so connected component labeling and bounding box filter has applied to remove unnecessary items. The blood cell has labeled with different colors and then color based segmentation has used. Different gray scale value has been used to each blood cell and segmented them from each other which are shown through rectangle box as shown in given below figures.

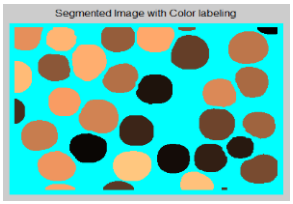

Fig.13. Color Clustering of Segmented Image

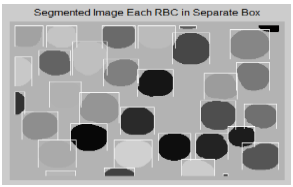

Fig.14. Segmented RBS separate inside box

After proper segmentation from each of blood cell from other, each of the cells extracted and collected for test through Neural Network. The extracted bold samples are shown below.

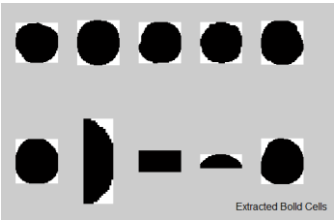

Fig.15. Extracted RBC

The extracted blood cell applied to neural network with six hidden nodes and sigmoid type activation function as discussed earlier. Then it classifies the RBC whether it is normal or abnormal then count it to store the result as RBC count. The classified result shown below, where normal blood cell represented with lower gray values and abnormal blood cell are represented with higher gray values.

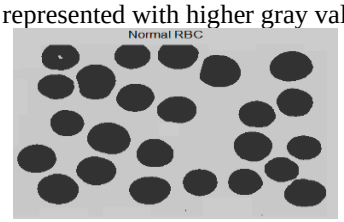

Fig.16. Normal RBC

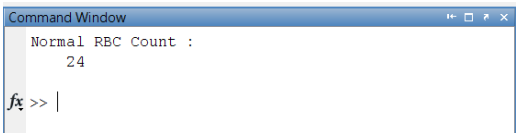

Fig.17. Normal RBC Count

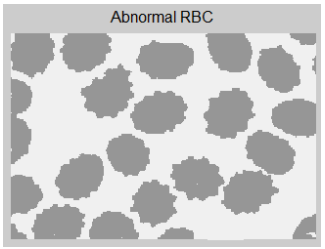

Fig.18. Ab-normal RBC

Fig.19. Ab-normal RBC Count

The following table represents some of the result samples out of the taken validation images.

Table- I: Some sample result for a set of 10 image data

Blood smear image	Normal or Abnormal RBC	Count
Testim1	normal	25
Testim2	normal	28
Testim3	abnormal	23
Testim4	normal	30
Testim5	abnormal	25
Testim6	abnormal	22
Testim7	abnormal	24
Testim8	normal	31
Testim9	normal	28
Testim10	abnormal	24

V.CONCLUSION

In the proposed method an automatic classification and counting system has been implemented which classify the RBC into normal and abnormal cluster. The system implementation propagates through three main blocks which are segmentation & processing, feature extraction and classification. During simulation each blocks gave a good performance with minimal error. The Otsu segmentation method applied on green color channel image with a series of post processing filter (morphological and connected component labeling) is found very effective to extract RBC shape from the background. For the feature extraction, shape information like area and perimeter have considered and moment invariant as the second feature criterion. The moment invariant feature is best suited because it is translation, scaling and rotation invariant. During classification it has been found that the ANN system effectively classifying the RBC from normal to abnormal.

The ANN is well performing with 8 hidden nodes and sigmoid type activation function. The proposed method tested on RBC in blood cell images, and the results showing around 90 percentage of accuracy.

The proposed system is limited to non-overlap cells. In future the system can be improved to implementation for overlap cells. It can be done by using marker based watershed segmentation with distance transform. It has been planned to execute the system with more sample sets to determine the generality of the proposed method.

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