IMAGE ANALYSIS SYSTEM FOR DETECTION OF RED BLOOD CELL DISORDERS USING ARTIFICIAL NEURAL NETWORK

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Abstract:-

This paper gives you an idea about the possible accurate and faster ways to detect and diagnose red blood cell disorders and describes the method to detect few RBC disorders i.e. sickle cell, tear drop, echinocytes, Howell jolly, macrocytes and microytes which are present in the blood samples images acquired from the light microscope. As the need of mankind is ever increasing for easy and effortless life, it is necessary to support human life with reliable, affordable and sophisticated medical aids. These RBC disorders are life threatening diseases and enormous global health problem, rapid and accurate medical aid is necessary. One of the areas of developing science that is growing rapidly for the detection of these disorders is the automated disease detection without human intervention. Visual inspection of microscopic images is the most widely used technique for detection of such disorders and this method needs man labor and it is time consuming so in order to overcome this disadvantage we will take the support of artificial neural network.

Keywords:- component; sickle cell; tear drop; macrocytes; microcytes; echinocytes.

1. Introduction

1.1 Macrocytosis

Macrocytosis is the enlargement of red blood cells with near-constant hemoglobin concentration, and is defined by a mean corpuscular volume (MCV) of greater than 100 femtolitres (the precise criterion varies between laboratories) Most commonly (especially when the increase in size is mild, and just above normal range) the etiology is bone marrow dysplasia secondary to alcohol abuse and Chronic alcoholism. Other causes may include:

- Megaloblastosis (Vitamin B12 or folate deficiency; or DNA synthesis-inhibiting drugs)
- hypothyroidism
- reticulocytosis (commonly from hemolytic or a recent history of blood loss).
- liver disease
- myeloproliferative disease
- Pregnancy- is the most common and requires no treatment as female will return back to normal post-partum.

1.2 Microcytosis

Microcytosis is a condition where red blood cells are unusually small when their mean corpuscular volume is measured. It is also known as "microcythemia". When associated with anemia, it is known as microcytic anemia. Microcytic anemia is not caused by reduced DNA synthesis (source). Thalassaemia can cause microcytosis. Depending upon how the terms are being defined, thalassaemia can be considered a cause of microcytic anemia, or it can be considered a cause of microcytosis but not a cause of microcytic anemia.

1.3 Howell Jolly

Howell-Jolly bodies are histopathological findings of basophilic nuclear remnants (clusters of DNA) in circulating erythrocytes. During maturation in the bone marrow erythrocytes normally expel their nuclei, but in some cases a small portion of DNA remains. It is named for William Henry Howell and Justin Marie Jolly. This DNA appears as a basophilic (purple) spot on the otherwise eosinophilic (pink) erythrocyte on a standard H&E stained blood smear. These inclusions are normally pitted out by the spleen during erythrocyte circulation, but will persist in individuals with functional hyposplenia or asplenia. Common causes of asplenia are splenectomy following trauma to the spleen, and autosplenectomy caused by sickle cell anemia. Ten percent of patients with coeliac disease also present with splenic atrophy with subsequent Howell-Jolly bodies. Other causes are radiation therapy involving the spleen, such as that used to treat Hodgkin lymphoma. Howell-Jolly bodies are also seen in: severe hemolytic anemia, megaloblastic anemia, hereditary spherocytosis, and myelodysplastic syndrome (MDS).

1.4 Acanthocytes

Poikilocytosis refers to the presence of poikilocytes in the blood. Poikilocytes are abnormally shaped red blood cellsas seen on a blood film in humans and many wild and domestic species of animals, though they are common in some clinically normal small ruminants, particularly goats.

Normal red blood cells are round, flattened disks that are thinner in the middle than at the edges. A *poikilocytes* is an abnormally shaped cell. Generally, Poikilocytosis can refer to an increase in abnormal red blood cells of any shape where they make up 10% or more of the total population.

1.5 Sickle Cell

Sickle-cell disease (SCD), or sickle-cell anemia (or anemia, SCA) or drepanocytosis, is an autosomal recessive genetic blood disorder with over dominance, characterized by red blood cells that assume an abnormal, rigid, sickle shape. Sickling decreases the cells' flexibility and results in a risk of various complications. The sickling occurs because of a mutation in the hemoglobin gene. Life expectancy is shortened. In 1994, in the US, the average life expectancy of persons with this condition was estimated to be 42 years in males and 48 years in females, but today, thanks to better management of the disease, patients can live into their 50s or beyond. In the UK, the current life expectancy is estimated to be 53–60 years of age.

2. Need of the project

Visual inspection of microscopic images is the most widely used technique for current determination of these blood disorders. Microscopy of Giemsa stained thick and thin blood films are used for the current standard determination of malaria. In peripheral blood sample, visual detection and recognition of *Plasmodium spp* is possible and effect via a chemical process called (*Giemsa*) staining. The staining process slightly colorizes the red blood cells (RBCs) but Highlights *Plasmodium spp* parasites, white blood cells (WBC), and platelets or artifacts. The detection *Plasmodium spp* requires detection of stained objects. However, to prevent False diagnosis, the stained objects have to be analyzed further To determine if they are parasite or not.

Although the microscopy has good sensitivity and allows Species identification, there are some drawbacks.

- Visual inspection of microscopic images is time consuming and exhaustive. If the detection & counting process is interrupted, the operator has to start over again from the scratch.
- Different cells in microscope images can be differentiated by human visual analysis by using only the spatial and intensity information.
- After the blood cell slides have been analyzed, they are Kept away. There is no quick and easy way of Retrieving analyzing lot of images for future reference as with a computerized system.
- Some decision makers in emergency situations may not have accessed to test results before having to decide on treatment and they may have no experience of a particular rare condition and therefore not

recognize it or not know how to deal with it. Or when they meet a very complicated case, he/she will discuss with several experts in order to take the best strategy for this case.

- Emotional problems and fatigue degrade the expert's performance. Standardized automated image analysis software would circumvent limitations associated with manual determination.

3. Materials And Methods

3.1 Image processing task prior to Artificial Neural Network

Artificial Neural Network (ANN) has been employed together with image processing techniques to automate the assessment of these blood disorders using the morphological features of erythrocytes in the blood. Prior to training, the first necessary step is to preprocess the giemsa stained blood sample images acquired from using a high resolution digital camera mounted on a microscope. But the images were in various magnification factors, color depths and images sizes. These acquired digital images were prone to a various types of noise which reduce the image quality. To prepare this data set for training and testing, common image processing tasks were performed on the digital images. Some of them are image enhancement, edge erosion, color and size normalizing, extraction of physical features, gray level.

3.1.1 Color Normalization

It is essential to apply color normalization to the images in order to decrease the effect of different light sources or sensor Characteristics (e.g. intensity, white balance). Among many computational color consistency algorithms based on the different models of illumination change, we have chosen to use an adapted gray world normalization method. According to this method it is assumed that the color in each sensor channel averages to gray over the entire image. If it is not so, we wish to rotate the cluster to the main diagonal. Gray world normalization method based on the diagonal model of illumination change which utilizes certain characteristics of microscopic peripheral blood images. Gray level normalization assumes that there is a constant gray value of the image which does not change among different conditions. In the diagonal model, an image of unknown illumination $\boldsymbol{I}_u$ can be simply transformed to the known illuminant space $\mathbf{I}_k$ by multiplying pixel values with a diagonal matrix ($\mathbf{I}_{krgb}(x) = \mathbf{MI}_{urgb}(x)$). Where μ_{Irgb} are the means for channels *r,g,b*. For the ordinary images, a normalization with transformation using the average values yields poor results. However, the images subject to this study contain two basic components (plasma and the rest) which can be separated by a foreground and background segmentation. Hence, the gray value assumption can be successfully incorporated in to normalization process. In this method, the input

image is first separated into foreground and background regions. According to the method described in [3] which use area morphology to estimate size of cells and then extracts foreground objects and estimates histograms. This procedure is quite efficient for the normalization of the image with respect to global illumination and staining effects.

3.1.2 Extraction of the physical features

Based on the morphological disorders various physical features of from the red blood cells where extracted. In the following part we give the process of extracting the features for different disorders.

- For sickle cell and tear drop cells the major axis, minor axis, and area of the cells in image was extracted. By comparing the major axis and minor axis multiplying factor an the area of the cells, the disorder is detected.
- For the macrocytosis and microcytosis the area of cells was found out. Out of all the areas the maximum and minimum area was found out. Comparing these values using the thresholding values, we can conclude the disorder.
- For Howell jolly bodies the solidity of the image was found. And if the image cells have solidity in them then the Howell jolly bodies are present in the cells.
- For detection of acanthocytes, a template from the image of the cells containing the acanthocyte cell is extracted. Using the images to be tested the image and template are matched.

After finding all these parameters a threshold value appropriate to the disease was set and the tested if the disorder was present or absent.

3.2 Training of two neural networks with the features extracted

Artificial neural network is a computational model inspired from neurological model of brain. The human brain computes in a different way from a digital computer (the von-Neumann machine). No doubt ANN is highly complex, non-linear and it needs parallel computing, but many times it is even faster than a computer in pattern recognition, perception and motor control. ANN also has a great structure and the ability to build up its own rule by experience and its advantages like non-linearity, input-output mapping, adaptivity. It also has plasticity which means, it has the ability to adapt its own environment. But learning is the major emphasis of a neural network.

Artificial Neural Networks (ANN's) have proven to be a promising paradigm for Intelligent Systems. Neural networks have been trained to perform complex functions in various fields of application including pattern recognition, identification, classification, speech, and vision and control systems. ANN's have the advantage of learning by example and the ability to generalize from their training data to other data. They are

fault tolerant in the sense; they can produce correct outputs from noisy and incomplete data. ANN's are relatively inexpensive to build and train.

These features of ANN's prompted us to look for a ANN based solution for the RBC disorder detection tool. Feed Forward Back propagation neural network architecture developed by Paul Werbos was chosen as it was a simple and one of the most commonly used ANN's. In this type of ANN a new input could lead to correct output provided that the input being presented was similar to the inputs used in training the network. This generalization property makes it possible to train a network on a representative set of input/target pairs and get good results without training the network on all possible input/output pairs. Another reason to chose back propagation was its ability to perform pattern classification on data where the input and the output had no linear relationship, as in the case of this application. The reason we use MLP rather than using other algorithm is that no activation function are required. And also this two hidden layers are more than sufficient to solve any problem.

3.3 Test and results

This study provides a good basis for those who are aiming to investigate the automated blood analysis for screening of red blood cell diseases. We have presented a morphological system to segment blood images. The extraction of features of red blood cells achieves a reliable performance. Shaped base features are generated for classification. In our study we use the multilayer Perceptron (MLP) classifier to find the better accuracy classifier for training the neural network.

The classification accuracy of 73.57% with three layers ANN was achieved in the study. The mean square error, the gradient and the number of correct recognition of testing was achieved. Our study can also be made vast in the field of medical science by increasing the accuracy of the neural network.

Testing of the images was done using the MATLAB software as follows:

3.3.1GUI for macrocyte

Select the input file by clicking on the input image push button.

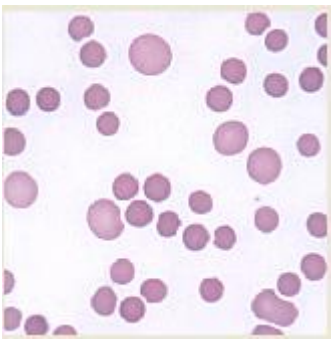


Fig. (3.3.1.1)

Click on the Preprocess button

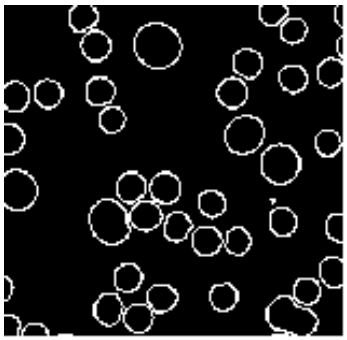


Fig (3.3.1.2)

Click on the Feature extraction button

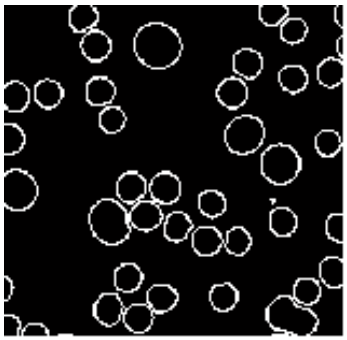


Fig (3.3.1.3)

Click on the MLP classifier to get the output text

The Disorder is Macrocytes

Fig (3.3.1.4)

3.3.2GUI for microcyte

Select the input file by clicking on the input image push button.

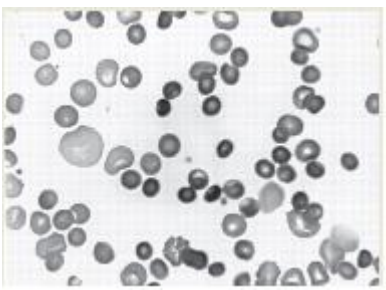


Fig (3.3.2.1)

Click on the Preprocess button

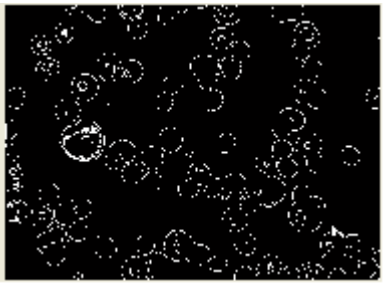


Fig (3.3.2.2)

Click on the Feature extraction button

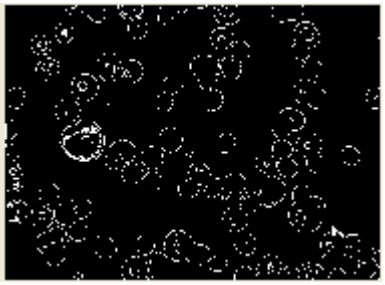


Fig (3.3.2.3)

Click on the MLP classifier to get the output text

The Cell is Microcyte

Fig (3.3.2.4)

3.3.3 GUI for Howell Jolly Body

Select the input file by clicking on the input image push button.

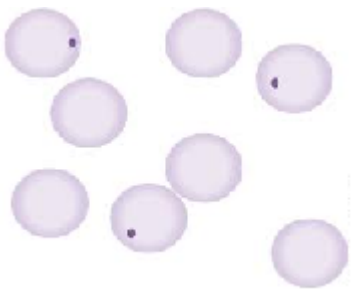


Fig (3.3.3.1)

Click on the Preprocess button

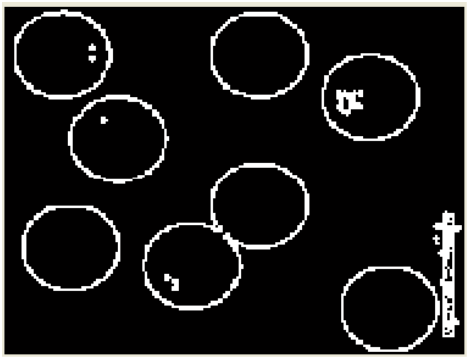


Fig (3.3.3.2)

Click on the Feature extraction button

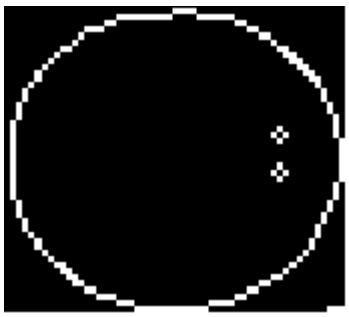


Fig (3.3.3.3)

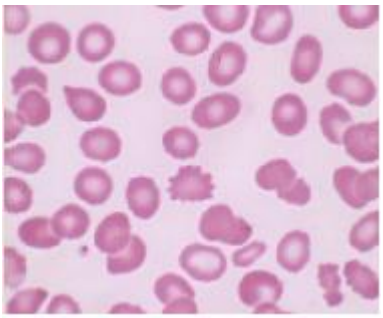
Click on the MLP classifier to get the output text

The Disorder is Howell Jolley

Fig (3.3.3.4)

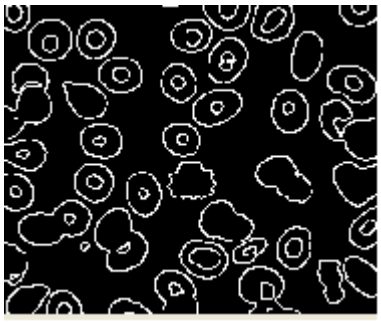
3.3.4. GUI for Acanthocytes

Select the input file by clicking on the input image push button.



Fig(3.3.4.1)

Click on the Preprocess button



Fig(3.3.4.2)

Click on the Feature extraction button

Fig (3.3.4.3)

Click on the MLP classifier to get the output text

The Disorder is ACANTHOCYTES

Fig (3.3.4.4)

3.3.5. GUI for sickle cell

Select the input file by clicking on the input image push button.

Fig (3.3.5.1)

Click on the Preprocess button

Fig (3.3.5.2)

Click on the Feature extraction button

Fig (3.3.5.3)

Click on the MLP classifier to get the output text

The Disorder is Sickle cell

Fig (3.3.5.4)

3.3.6 GUI for Tear drop cells

Select the input file by clicking on the input image push button.

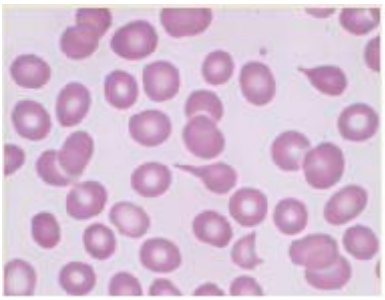


Fig (3.3.6.1)

Click on the Preprocess button

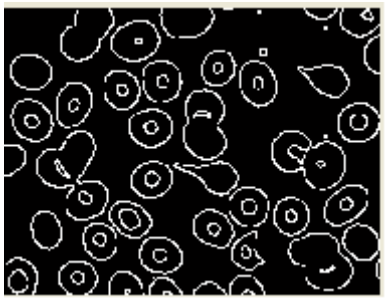


Fig (3.3.6.2)

Click on the Feature extraction button

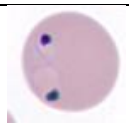
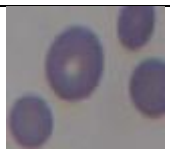
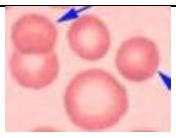
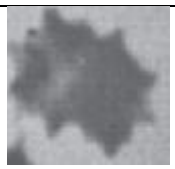
Fig (3.3.6.3)

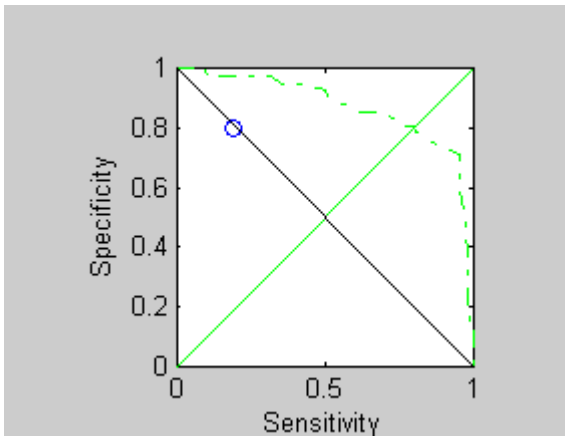
Click on the MLP classifier to get the output text

The Disorder is Tear Drop

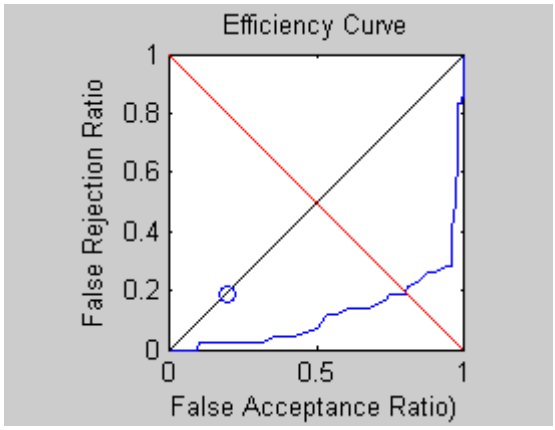
Fig (3.3.6.4)

The results after training the neural network was as follows:

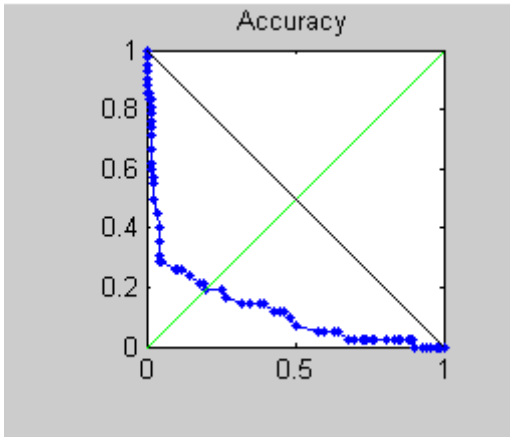
	Sickle cell	Howell jolly	Tear drop	Macrocyte	Microcyte	Acanthocytes	Normal
Blood image							
Perfor-mance output	**1.92e-05**	**2.17e-4**	**7.86e-9**	**2.86e-4**	**9.38e-9**	**5.94e-09**	**7.3e-09**



This graph shows that with increase in number of images, the sensitivity becomes less.



With increase in number of images it, the specificity increases.



With increase in number of images, accuracy decreases. Intra-class accuracy is observed more. As we take the efficiency for interclass disorders it decreases. But if we increase the numbe of samples in training and go ahead, two stage classifiers then accuracy can be increased.

4. Conclusion:

This study provides a good basis for those who are aiming to investigate the automated blood analysis for screening of red blood cell diseases. We have presented a morphological system to segment blood images. The classification accuracy of 73.57% with three layers ANN was achieved in the study. The mean square error, the gradient and the number of correct recognition of testing was achieved. Our study can also be made vast in the field of medical science by increasing the accuracy of the neural network.

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