ORIGINAL RESEARCH PAPER
Volume-8 | Issue-12 | December - 2019 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

AUTOMATIC LEUKEMIA DETECTION IN HUMAN BLOOD SAMPLE BASED ON MICROSCOPIC IMAGES USING MACHINE LEARNING

Oncology

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ABSTRACT

One of the major diseases which causes death among human is leukemia. Cure rate depends mainly on the early detection as well as diagnosis of the disease. The proposed method is about the method of automatic leukemia detection. In manual method, experienced physician counts white blood cells (WBC) inorder to detect leukemia from the images taken from the microscope. But, this method is time consuming and not so accurate, because it completely depends upon the physician's skill. Automatic technique of detecting leukemia is developed inorder to overcome these drawbacks.. These features are used as the classifier input. Image Processing, Segmentation, Fill hole operations, feature extraction and classification are done to obtain the cancerous blood cell. Support vector machine (SVM classifier) is used. The methodology is done by using Machine leraning with the aid of Matlab Software. Automatic detection of leukemia using microscopic human blood sample images and to classify the primary types of leukemia is the main goal of this method. The accuracy obtained is of 96.67%.

KEYWORDS

Feature Extraction, Leukemia, Machine Learning, SVM Classifier.

I. INTRODUCTION

Medical imaging is becoming one of the most important visualization methods in medical science over the past year. It has achieved large development of new and powerful instruments for transmitting, detecting, analyzing, and displaying medical images. This leads to the

large growth in the field of image processing techniques for solving medical problems. Main aim of analyzing images is to collect data, detection and curing of diseases, radiation therapy, monitoring and evaluation. Leukemia which results in death if it is detected late. The white blood cells(Wbc) produced abnormally by bone marrow can cause leukemia.When the blood sample is taken and is being examined by hematologists, abnormal blood cells can be detected. Microscopic images will be examined visually by hematologists and the process is time consuming and tiring. This process also requires human expert and is subjected to errors due to emotion interruption. So, its difficult to get compatible results from visual examination.It can only give accurate results for future research.

To overcomes related restrictions automatic image processing is usually needed in visual examination. To recognize the types of leukemia system to be developed will be based on the microscopic images obtained. For a particular type of leukemia, appropriate treatment is required. Segmentation error can occur and will also be increased. Another problem is ,there may be lack of adequate number of training samples, if supervised learning technique is employed,. Minimum training dataset is required when we use RL approach. At the initial stage, leukemia detection greatly helps in providing the proper treatment for a particular patient. Detection of leukemia begins with a complete blood count. If the counted WBC's are abnormal, the patient is then suggested to consult the doctor.

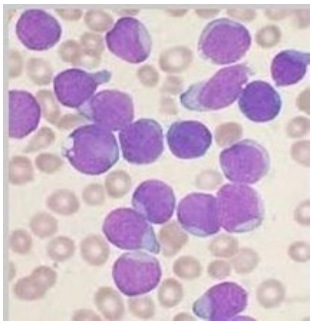

Fig. 1. Leukemia Image [1]

An evaluation of peripheral blood slide analysis and morphological bone marrow is almost done, in order to confirm the presence of leukemia cells. A hematologist will observe some cells under the microscope for examining the abnormalities presented in the nucleus or cytoplasm of the cells, in order to classify the abnormal cells in their particular types and subtypes of leukemia.

Treatment must be given to the patient and the disease which can be predicted using this type of classification. In the case of leukemia, large no: of abnormal WBC produced by bone marrow. Manual detection of leukemia which leads to time consuming and it is also highly expensive due to high cost pathological instruments. So, inorder to get faster and accurate results, automatic technique of detecting leukemia is developed. So, in this technique, images of human blood samples are collected and processed and nucleus part is then segmented. Finally, samples are classified whether they are cancerous or normal cells.

II. BACKGROUND

Leukemia is one of the major cancer and it is mainly found in the bone marrow. Normal human blood cells can develop in the bone marrow itself called Stem cells.It forms different kinds of blood cells. Stem cells are divided into two: Myeloid stem cell and Lymphoid stem cell. A myeloid stem cell is further divided to form RBC, platelets, and White blood cells. A lymphoid stem cell can also produces different types of WBC such as B cells or T cells.

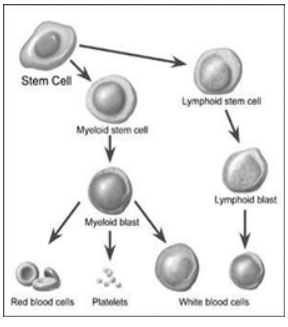

Fig. 2. Stem Cell Type [12]

II. Leukemia Cells

The abnormal and unshaped WBC which are produced in the bone marrow.ie, abnormal blood cells is called leukemia. Abnormal Wbc attacks to the normal white blood cells, normal RBC, and normal platelets. This makes difficult for normal human blood cells for their proper functioning. Leukemia based on their type will develops in the human body and quickly spreads and captures different parts of the human body.In generally there are two types of leukemia: Chronic and Acute leukemia.

A. CHRONIC LEUKEMIA

Chronic leukemia which captures human body very slowly. Initially,

chronic leukemia infected by a patient will not cause any symptoms. ie, normal WBC works normally and thus abnormal or leukemia cells will not affects the functioning of normal cells.

In this way, chronic leukemia spreads very slowly and captures maximum area of body of the patient begins to getting the symptoms. Finally, patient needs to consult the doctor and leukemia is in its final stage. Common types of chronic leukaemia are of two types:

I. CHRONIC LYMPHOCYTIC LEUKEMIA (CLL)

Chronic Lymphocytic Leukemia (CLL) normally catches the older ones. That means, the person who suffer from 20-25 years from blood pressure, diabetes etc..The person whose age is more than 50 year can cause this type of leukemia. CLL will not cause any symptoms so that patient cannot find the leukemia in its initialstage. If patient shows symptoms such as fatigue, weakness and weight loss, patient should consult the doctor.CLL is shown in Fig 3

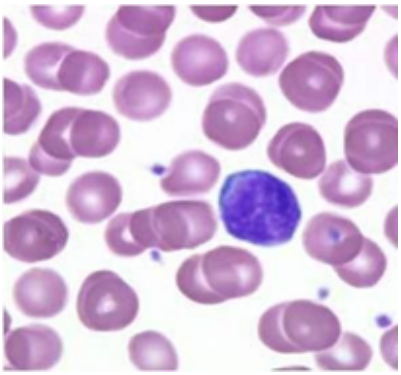

Fig.3. Chronic Lymphocytic Leukemia[12]

1) CHRONIC LYMPHOCYTIC LEUKEMIA SYMPTOMS

Chronic lymphocytic leukemia(CLL) is a slow growing cancer which shows many symptoms. It will not show clear symptoms in its initial stage. At the last stage of CLL, patient will suffers a lot, but medical science cannot help the patient. Some of the conditions developed by CLL includes:

1) Anemia: O2 transported by RBC which is provided for the body. If the abnormal WBC affects the functioning of red-blood-cells, it will leads to anemia. Symptoms of anemia includes weakness, fatigue, lethargy and difficulty in breathing.
2) Leucopenia: Functioning of WBC produces antibodies and thereby preventing disease. If the abnormal white blood cells affects the functioning of normal WBC, leucopenia will arise. Symptoms of leucopenia are lower immunity, infections and fevers.
3) Thrombocytopenia: Blood platelets are the particles which aids in blood clotting. If the abnormal WBC affects the functioning of normal blood platelets, thrombocytopenia will occur and the symptoms which may includes easy bruising, nose bleeding, and bleeding of gums.

II. CHRONIC MYELOGENOUS LEUKEMIA (CML)

Chronic Myelogenous leukemia(CML) can be detected at any age between 35 and 45 years. In CML, symptoms at the beginning stage are weight loss and fatigue which may causes upper left abdominal pain. CML cell is shown in

Fig 4. CML will present in the bone-marrow of a patient at the intial stage and after that, it will spreads through the whole body of a patient.

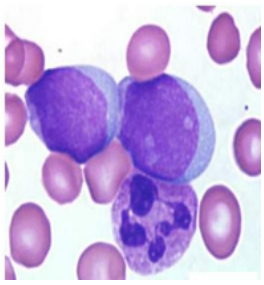

Fig .4. Chronic Mylogeneous leukemia [12]

A. ACUTE LEUKEMIA

In Acute-leukemia type, the no: of leukemia cells increases rapidly and quickly and also spreads all the other parts of the body. At the final stage, medical science & doctors cannot help the patient to fight with the leukaemia. Acute leukemia are of 2 types:

I. ACUTE LYMPHOCYTIC LEUKEMIA (ALL)

ALL is mostly seen in the children aged between 1 & 12 years old and also seen at the older age. Symptoms at the beginning stage of patients shows fever, tiredness and bleeding. ALL cell is shown in Fig 5. It shows symptoms such as Fatigue, weakness ,fever, Headaches Pale skin, Vomiting, Body pain and Loss of appetite.

ALL can be sub classified into two :Benign and malignant

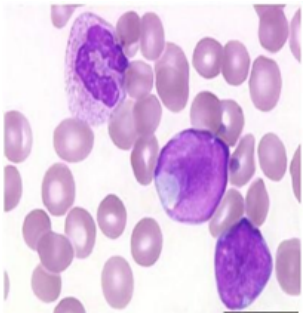

Fig. 5. Acute Lympocytic Leukemia[12]

II. ACUTE MYELOGENOUS LEUKEMIA (AML)

Acute myelogeneous leukemia (AML) usually occur in kids whose age is less than one year and rarely occur in the children whose age is greater than 2 years. It may also seen in the older patients. For an AML, 25% of patients shows intial symptoms such as body and joint pain. And fifty percent patients shows spleen enlargement, but enlargement of lymph node occurs rarely. AML cell is shown in Fig.6.

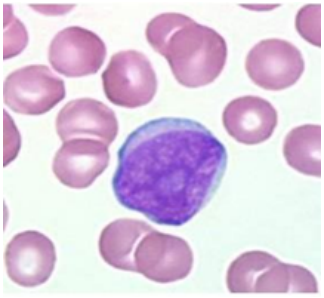

Fig. 6. Acute Myolegeneous Leukemia[12].

1) AML SYMPTOMS

A. FREQUENT FEVER AND INFECTIONS

Main role of WBC is to prevent infections and protects the human body from foreign bacteria. AML reduces the number of healthy Wbc. .As the result, body is not capable of fighting against foreign germs. Patients having AML might have an increased rate of fevers and infections.

B. ANEMIA:

Main role of RBC is to carry O2 throughout the human body. Abnormal blood cells caused by AML leads to feeling tiredness and also having difficulty in breathing.

C. EASY BRUISING:

The function of platelets is to control bleeding. If the abnormal blood cells affects the working of normal platelets, such patients may occur minor cuts, bleeding may occurs and also it causes slow healing of wounds.

D. JOINT & BONE PAIN

Increased number of leukaemia cells can cause bone/joint pain or both.

IV. LITERATURE REVIEW

Many attempts have been made before inorder to develop systems which helps in segmentation & classification. There are 4 major techniques in segmentation: thresholding, boundary-based/region-based segmentation and hybrid techniques [8]. Edge-based schemes

are more popular in case of peripheral blood/bone marrow smears [5]. Combination of both boundary & region information provides better results than those obtained by individual method [8]. A lot of segmentation algorithms were presented in literature, including [11], [6], and [10], where Otsu- segmentation & automated histogram thresholding were used to segment WBC from the blood sampled images. Contour signature is employed in work [3] inorder to detect the irregularities in the nucleus boundary.

Selective Filtering Is Employed In Work [2] inorder to segment leukocytes from the blood components. Hue, saturation, and value is employed in work [7] (where, hue indicates color, saturation indicates the range of gray in the colour space, and value indicates the brightness of the colour, it varies with color saturation), color space. To segment the nucleus from the surrounding cytoplasm of cervical cancer images, watershed segmentation algorithm is used and it was proposed in [4]. An unsupervised colour segmentation is also employed in work [9] to count the WBC from leukemia images. Main disadvantage of these systems are, this can classify only sub-images. But, the main aim of this project is to implement a fully automatic classifier based system for the detection of leukemia from the microscopic blood sampled images.

V. PROPOSED METHODOLOGY

The Fig 7 shows, Proposed methodology is to detect Leukemia automatically from the microscopic images

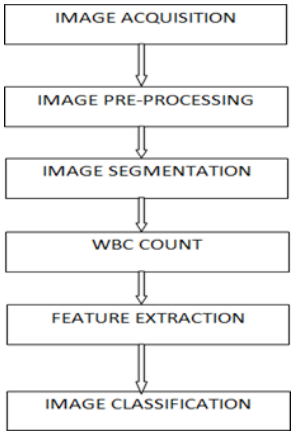

Fig.7. Proposed Methodology[13]

A. IMAGE ACCQUISITION

In this section,better resolution images are taken by the microscope. Datasets are collected from the American Society of Hematology (ASH) from their image bank of leukemia cells. It is an online based image library consists of neumerous collections of microscopic blood images related to a wide range of hematology categories. They are also providing good quality images captured using different microscopes in different resolutions.

B. IMAGE PRE-PROCESSING

Images which are taken in microscope may have some noises,unclear etc. In this section of image processing, removing those unwanted noises making the images suitable for the further step of imaging process. Pre-processing usually includes contrast enhancing, noise removing, etc. In order to remove the noise, median filtering technique is commonly used.

1)CIELAB COLOUR FEATURES AND COLOUR CORRE LATION

RGB colour images are normally produced by the digital microscope, which is difficult to segment.With respect to color and intensity, blood cells and image background varies greatly. Settings in camera, illumination variation are the reason for this. In order to make the segmentation of the cell robust with respect

to these variations, an adaptive procedure can be used. RGB i/p image is converted into CIELAB or CIEL*a*b color space. The parameters 'a' and 'b' are used to make accurate color balance corrections.In L*a*b* color space, dimension *L* represents the lightness of the color, dimension *a** represents the position between red/magenta & green, and dimension *b** represents the position between blue & yellow.

C. IMAGE SEGMENTATION

One of the most important section in the technique of image processing. To identify and count Wbc from the other cells is very important. This is done through img segmentation. Segmentation can be done in many ways. Here, we use k-means clustering algorithm for the segmentation process. This technique gives the better result..

1) K-MEANS CLUSTERING ALGORITHM

It needs 3 user-specified parameters. Inorder to assign every pixel to one of the clusters, k-means clustering method is used., Every pixel is assigned to one of these classes, using the properties of the cluster center.Based on the corresponding a and b values in L*a*b color space, each pixel of an object is classified into *k* clusters. By calculating the Euclidean distance between the pixel and each color indicator, each pixel in the L*a*b color space can be classified into *k* clusters. These clusters correspond to nucleus (high saturation value), background (high luminance and low saturation value).

Depending upon the min distance from each indicator, each pixel of the whole image is labeled to a particular color.The cluster which contains the blue nucleus is taken only in consideration which is required for the feature- extraction. Some of the segmented images by performing *k*-means segmentation, it was observed that, only the edges of the nuclei were obtained. In order to overcome this shortcoming, morphological filtering is used. Depending upon the features to be extracted, an image is partitioned into several regions. Visibility as well as perceptibility of these regions can be improved by using morphological filtering. In order to obtain the desired outcome, the following actions can be performed. Once these actions are performed, the following texture andshape-based features are extracted from the whole images:
Edge enhancement- to enhance the borders of the membrane and the cells

Canny edge detection- to obtain o/p with continuous edges.

Dilation- to connect the points of the membrane. *Hole-filling*-to fill the internal holes of the connected element having the largest area

D. FEATURE EXTRACTION

Some features are extracted from the processed image in feature extraction. It is the process of collecting some data from the sampled images and we can check the corresponding values of data with the standard value ,Thus we can differentiate easily that the image is cancerous cells or not. ie, transforming the i/p data into the set of features is called *feature extraction*. This phase is used to find out the features of the nucleus of the leucocytes (WBCs).By feature extraction, classifier performance is greatly influenced. So, correct choice of features are the most important step. By using these features of the whole images in our system, implementation will be done. These features are considered to improve the classifier performance.

I. LOCAL BINARY PATTERN (LBP)

For texture classification concept of local binary pattern (LBP) is introduced. There are many advantages

LBP texture features have the following characteristics:

- Robust against illumination changes
- Very fast to compute
- Do not require many parameters to be set
- Have local features
- Perform very well in many computer vision image applications.

Each pixel is replaced by a binary pattern which is derived from the pixel's neighbourhood in LBP Patten. Each gray scale 'P' of an image is used as a center of a circle with radius R=1 or R=2(R is usually kept very small). Each gray scale P is then compared with these sample points one by one.

II. SHAPE FEATURES

1) GEOMETRIC FEATURES:

Area, perimeter, centroid, eccentricity, compactness,convexity, concavity, rectangularity, elongation, solidity etc.

2) TEXTURE FEATURES/LBP FEATURES:

Entropy, Standard deviation, covariance, kurtosis, skewness.

3) STATISTICAL FEATURES:

Mean, variance, standard-deviation, skewness etc.

4) GLCM FEATURES
Autocorrelation, contrast, energy, homogenity, maximum probability

E. IMAGE CLASSIFICATION
All these features are calculated as well as extracted and are listed in a column with their values. So, we get a matrix called feature extracted matrix. The image to be tested is called test image. Values of the test image features are checked with the previously calculated values based on the values of the input test image. Support Vector Machine (SVM) classifier algorithm will classify whether the tested image has infected cell or not.

VI. SIMULATION RESULTS

I. Figures obtained using MATLAB

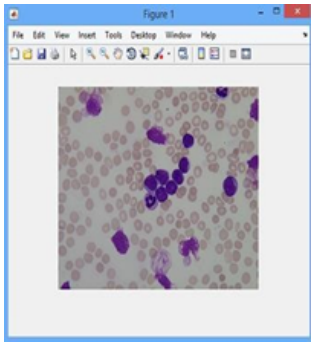

Fig. 8. Original Image

Fig. 9.Applying K means clustering algorithm(RGB to CIELAB)

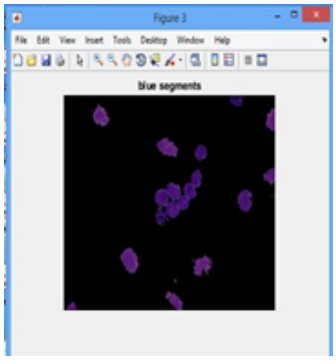

Fig. 10. Detection of white cell using K means

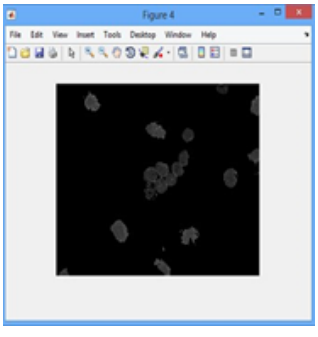

Fig. 11. RGB to Gray scale image Clustering.

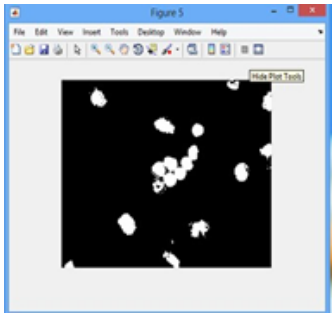

Fig.12. Gray to Binary image

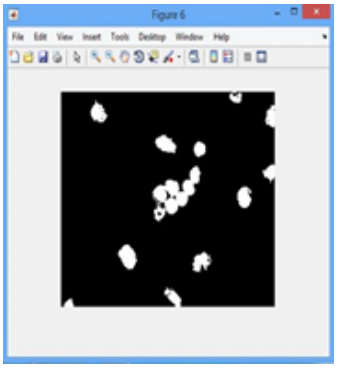

Fig. 13. Morphological filtering

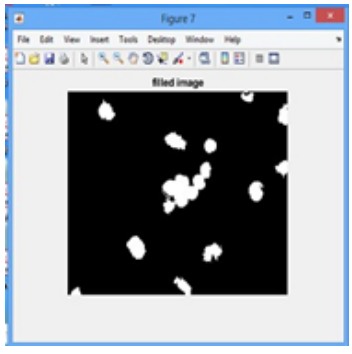

Fig. 14.Hole filling (Final Segmented image)

VII. RESULT
The main aim of this project is, automatic detection of leukemia using blood sample images obtained from the microscope and to classify the primary types of leukemia. This method is used to detect whether the person has leukemia or not,on the basis of Wbc Count and to identify the type of leukemia .This proposed method mentioned in this paper has achieved an accuracy of 96.67%.

It can classify the primary types of leukemia such as AML,CML,ALL and CLL by determining changes on texture, geometry, colors and statistical analysis as a classifier i/p and thereby detecting whether the person has leukemia or not. It can also detect the type of leukemia.

VII. CONCLUSION
The main goal of this project is automatic counting of WBCs inorder to detect leukemia from the image taken from the microscope. Manual counting process for the detection of leukemia is time consuming and gives inaccurate result. So ,inorder to save livesand to get more accuracy, this automated method is proposed. The main aim of this method is, automatic leukemia detection using microscopic images of human blood sample .Thus classify the primary types of leukemia and thereby diagnosing the disease. The accuracy obtained by the proposed method is 96.67%.

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