



Automatic Leukemia Detection by the Implementation of Image Processing Techniques and Predict the Leukemia Stage

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ABSTRACT:

Leukemia, which is a common disease nowadays, develops when the bone marrow produces an abundance of dysfunctional white blood cells. The hematologists utilize microscopic examination of human blood necessitates with the help of different processes like segmentation, classification, and grouping. The Haematologists visually examine the microscopic photos, which is a laborious and time-consuming operation. Computerized image processing technology is an essential tool in this application and can get beyond related visual examination limitations. In this communication, we proposed a microscopic imaging-based Leukemia detection algorithm. Early and prompt detection of Leukemia is extremely helpful in determining the best course of treatment. White blood cells are initially segmented using statistical characteristics like mean and standard deviation, which separates them from other blood components like erythrocytes and platelets. Geometrical characteristics like the area and periphery of the white circulation cell nucleus are examined for the diagnosis and prognosis process. A significant number of photographs have been successfully processed using the suggested method, with results that are encouraging for images of various qualities. With the help of the widely used simulation software MATLAB, we have introduced a novel method that results in the prediction of leukemia considering other factors like the percentage of myeloid cells, homogeneity, energy, correlation, contrast, etc.

Keywords: Leukemia, white blood cells, MATLAB, image processing

I. Introduction-

Leukocytes, also referred to as white blood cells or WBCs, are an essential part of the immune system that defends against bacteria, viruses, and other foreign substances. These blood-circulating, nucleated cells are generated by human bone marrow and can be found all across the lymphatic vessels [1]. Leukocytes are different from other blood cells like red blood cells and platelets, so they are primarily divided into two types based on cell structure (agranulocytes and granulocytes) and cell heredity (lymphoid and myeloid). As seen in Figure 1, these five subcategories of leukocytes include neutrophils, basophils, eosinophils, lymphocytes, and monocytes. Thymus (T cells), bone marrow (B cells), and natural killer (NK or K) cells are the three cell types that makeup lymphocytes [2]. However, the immune system is impacted by the malignant production of aberrant and immature leukocytes, which reduces the capacity of the bone marrow to make RBCs and platelets [3]. The condition known as Leukemia is characterized by the growth of leukocytes, or blasts, in the bloodstream and the bone marrow. The formation of healthy blood cells is decreased by the aberrant development of malignant immature leukocytes known as blast outcomes or cells [4]. Complete blood count, often known as CBC, is frequently used as a disease indicator since it is important to maintain a certain number of granulocytes in the blood. Leukemia's precise causes are unknown, possibly as a result of genetic and environmental factors. However, because aberrant leukocytes move quickly through the bloodstream and harm other body organs, a Leukemia diagnosis at an early stage is essential [5].

The bone marrow malfunctions in a person with leukemia. Leukemia cells, which are aberrant, immature cells, are created in the bone marrow. In most cases, "blasts" are used to describe leukemia cells. In the bone marrow, these adolescent cancer cells displace other blood-forming cells. A youngster may experience anaemia and extreme fatigue if the bone marrow is unable to produce many RBCs to carry oxygen. Blood won't clot properly and also the patient may hemorrhage readily if not enough platelets are created. When WBCs are insufficiently abundant, the body cannot combat pathogens, and the person may experience recurrent infections. There are two types of Leukemia: acute and chronic.

In a recent method, researchers proposed an algorithm where

Hossein Ghayoumi Zadeh et.al, an image analysis approach is used for automated detection, pre-processing, enhancement, segmentation, feature extraction, morphological and calorimetric classification of specific cells, especially the differentiation of cancer cells from normal cells.[6]

Minai D. Joshi et.al, prophesized to picture improvement and arithmetic for WBC segmentation, this research also suggests an automatic Otsu's Thresholding blood cell segmentation approach. Blast cells have been distinguished from regular lymphocyte cells using the K-NN classifier[7].

N. Z. Supardi et.al,comprehended an essay that describes a study that used KNN to divide acute leukemia's blasts into its two main types, ALL and AML. From blood pictures, 12 key elements representing size, color, and form were retrieved. To discover appropriate parameters to use in the approach of classifying the blasts, the k values and distance metric of the k-NN were examined[8].

FauziahKasmin et.al,described an early attempt to identify different forms of leukemia from tiny blood sample photos. It will make advantage of microscopic picture features to look at texture, geometry, color, and statistical 256 analysis changes. The classifier input will be changed to these features [9].

Lim Huey Nee et.al, demonstrated the gradient magnitude, thresholding, morphological procedures, and watershed transform are used in this study to conduct cell segmentation. The proposed method was tested on 50 photos, and the findings showed that it was successful in producing segmentation results that were of high quality[10].

NH Abed Halim et.al.proposed a study, where the image quality is enhanced via global contrast extending and separation based on HIS color space. The WBC image sample's nucleus region is extracted using an image enhancement process utilizing the same threshold level in both ALL and AML pictures[11].

Labati, RuggeroDonida,et.al, proposed a brand-new blood sample public dataset that was created especially for testing and comparing segmentation and classification algorithms. A precise list of merits and the classification of cells for each photo in the dataset are provided in order to objectively compare the results of various algorithms. The percentage of lymphocytes for leukemia detection will then be calculated using the number of counted blood cells[12].

II. Existing Methods:

Patient records and medical examination: The documentation of current symptoms and past health issues. Leukemia can also be diagnosed by looking at a person's family's medical history.

A full blood check (CBC): Blood is drawn and the quantity of RBCs, WBCs, and platelets is counted under a microscope.

Bone marrow aspiration: A needle is used to extract bone marrow from the breastbone. To check for aberrant cells, the sample is examined under a microscope after it has been extracted

Cytogenetic evaluation: A cytogenetic test uses bone marrow or blood to help identify certain chromosomes. It reveals chromosomal abnormalities that aid in the diagnosis and classification of the different types of Leukemia. Typically, results are ready in three weeks.

Immunohistochemistry: In immunohistochemistry, cells taken from blood samples are treated with specialized antibodies. The shift in color can be seen when viewed under a microscope. It aids in identifying the many cell types that are present.

III. Classes of Leukemia:

Depending on the type of afflicted leukocytes, there are different types or classes of Leukemia. Lymphocytic Leukemia is the name given to the kind of Leukemia that has immature lymphocytes; myelogenous Leukemia is the name given to the type of Leukemia that has immature monocytes and granulocytes [13].

Leukemia can generally be divided into acute and chronic in function as normal cells, with chronic Leukemia being the most severe type [14].

In the bone marrow and blood, lymphoblastic or lymphocytic Leukemia is a kind of malignancy. The immature blast cell with altered morphology known as a lymphoblast is activated by an antigen to become an adult lymphocyte [15]. According to morphological differences, the French American British divides ALL into three groups, L1, L2, and L3. The L1 cells have a uniform nucleus, no vacuoles, and cytoplasm inside of them. L1 cells are smaller than L2 cells in size. They have variable cytoplasm and an uneven nucleus. The cytoplasm of L3 cells contains vacuoles, and they have a uniform shape with a round nucleus [16].

Acute myelocytic leukemia, acute myelogenous Leukemia, acute non-lymphocytic Leukemia, and acute granulocytic Leukemia are the four most prevalent types of acute Leukemia that are particularly prevalent in elderly persons [17]. The development of juvenile blast cells other than lymphocytes is what distinguishes it [18].

The bone tissue may produce aberrant platelets and red blood cells in AML [19]. Anaemia, fever, mucous membrane ulcers, and granulocytic insufficiency are some of the signs and symptoms of AML [20], [21]. AML is distinct from other forms of leukemia as it involves the cells that make up myeloid cells.

The blast cells have been divided into Type I and Type II by FAB.

Chronic Lymphocytic leukemia is more frequent in men than in women and affects adults, especially those over the age of 60. In terms of symptoms, this type of leukemia is distinct from others, including swollen lymph nodes, anorexia, weight loss, weariness, etc.

Chronic myeloid leukemia is more common in young and middle-aged adults. Immature granulocytes are overproduced in CML and leak out of the bone marrow and into the bloodstream. With the increased accumulation of granulocyte, macrophages, myelocytes, and eosinophil myelocytes, the percentage

of myeloblasts is also less than 10%. Most of the time, myelocyte and neutrophil counts are higher than the proportion of normal leukocytes. Anaemia, weight loss, gradual spleen enlargement, fever, and night sweats are among the signs and symptoms of CML. A CLL patient's RBC count gradually decreases over time, and a lack of platelets is linked to anaemia, bleeding, and severe bleeding [18].

Leukemia can be identified through various commonly used techniques:

Blood smear analysis: Leukemia is typically diagnosed through a blood smear analysis. A glass slide is discoloured after a glob of blood has been smeared on it. With a microscope, the coloured cells can be examined to look for aberrant blood cell concentrations, sizes, and forms [23]. The irregularities can be automatically detected and measured using image processing techniques like segmentation and feature extraction [24].

Bone marrow biopsy: Leukemia may occasionally require abnormal bone marrow biopsy to be identified. A small portion of even more bone marrow is extracted as from hip bone during this surgery and examined. The photographs of the bone marrow sample can be examined using image processing techniques to find aberrant cells and determine their concentration [25].

Imaging scans: Leukemia can be found in the bones or other parts of the body using imaging studies like X-rays, CT scans, MRIs, and PET scans. For diagnosis, image enhancement techniques can be employed to improve the radiographs and highlight the problematic areas [26].

Flow cytometry: A laboratory method for examining the properties of specific cells is flow cytometry. Leukemia can be identified by examining the characteristics underlying blood or cells from the bone marrow. Techniques for image processing are capable of helping automatically analyse the data and spot aberrant cells [27].

A simple blood test that yields an abnormal blood cell count is frequently followed by a leukemia diagnosis. The doctor may take blood and bone marrow samples after leukemia is suspected to check the morphology of the cells. In order to identify surface-located proteins and chromosomal alterations, samples are also sent to the pathology lab. For the diagnosis of specific patients, this information is crucial [28].

IV. Methodology:

The work outline is forecasted as a flowchart in figure 1.

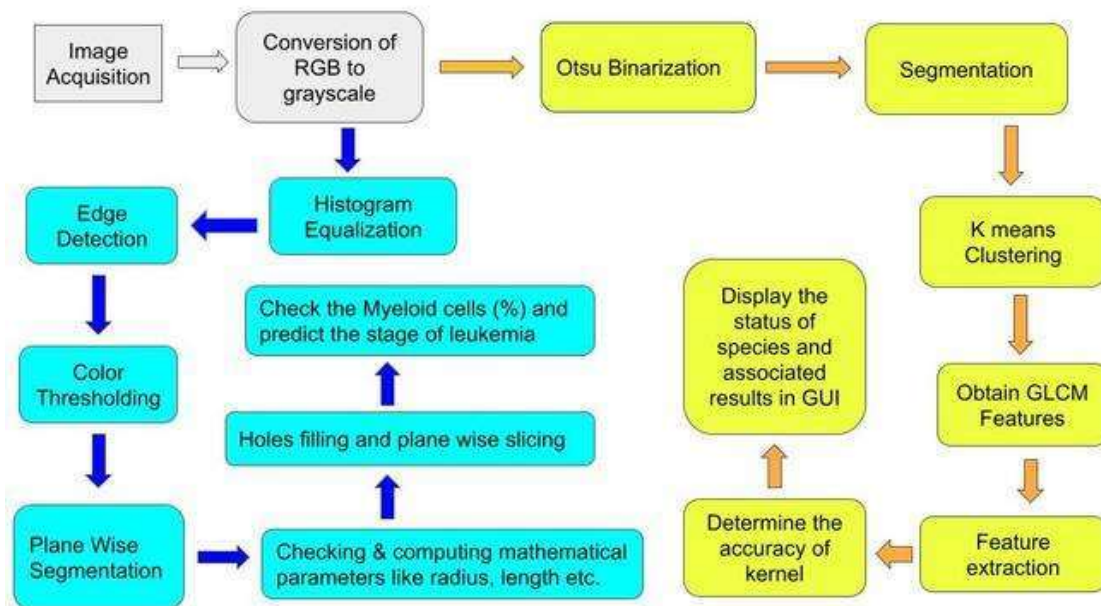


Figure 1: Methodology

From figure 1 it is depicted that after taking an image as input the simultaneous operation started after the image is converted into grayscale image. The two operations mainly correspond to the development of GUI and a predictive system. The process of converting an image into an electronic medium and carrying out specific operations to extract some valuable data from it is known as image processing. When implementing specific predetermined signal processing techniques, the image processing system typically wants to treat all images as 2D signals.

In the development of GUI ostu binarization is done initially to clear images for easier retrieval followed by segmentation, which is a crucial step in the image recognition process because it isolates the items that are of interest to us so that they can be processed further for recognition or description. Image segmentation is used to categorize image pixels in practice.

The unsupervised categorization algorithm K-means, also known as clusterization, divides individuals into k groups according to their traits. The process of grouping involves minimizing the total spacing between every object and the centroid of the group or cluster. The interest area is divided from the background using it.

The technique of turning raw data into quantifiable features that can be handled while keeping the information in the original data set is known as feature extraction. Compared to using machine learning on the raw data directly, it produces better outcomes. The number of redundant information contained in the information collection is decreased with the aid of feature extraction. In the end, the data reduction speeds up the learning and generalization processes and enables the model to be built with less machine labor. The number of redundant information contained in the information collection is decreased with the aid of feature extraction. In the end, the data reduction speeds up the learning and generalization processes and enables the model to be built with less machine labour.

Thus proceeding with all these steps the GLCM features namely contrast, energy, correlation, and homogeneity along with the accuracy of the kernel are displayed. The status of species is also displayed.

On the other end in the development of a predictive system after the conversion of RGB to grayscale, histogram equalization is done which is done to enhance contrast in photographs; equalization is a digital image processing technique. This is achieved by successfully extending the intensity spectrum of the picture and dispersing out the most common intensity levels.

Edge detection provides a method of image processing that locates the edges of objects in pictures. It operates by looking for changes in brightness. In fields including image analysis, machine vision, and machine vision, edge detection is utilized for image classification and data extraction.

Thresholding is a sort of image segmentation in which we modify a picture's pixel composition to facilitate analysis. With the process of thresholding, we turn color or grayscale images into binary images or one that is only black and white.

Plane wise slicing establishes the sufficiency of the numbers of bits employed to quantize each pixel, useful for image compression, and allows for the analysis of the relative strengths presented by each bit of the image.

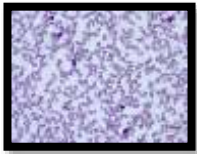
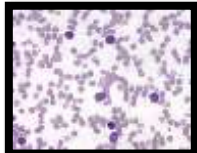
The fundamental mathematical editing techniques of histogram equalization, pattern recognition, curvelet transforms, Fourier transforms, difference equations, integration, matrix, and algebra are used in many of the image processing techniques. MATLAB is one of the most popular tools used by researchers in the field of image processing for computational purposes [22].

In the ultimate stage the myeloid cells are checked and the stage of leukemia is predicted.

V. Results and Discussions:

Image	Contrast	Correlation	Energy	Homogeneity	Accuracy	Species Result	Myeloid cell	Stage of Leukemia
Image 1	0.0459	0.3996	0.8797	0.9770	66.67%	Normal	30.102%	Advanced
Image 2	0.0049	0.8504	0.9620	0.9975	83.33%	Abnormal	3.53%	Initial
Image 3	0.0417	0.8151	0.7343	0.9791	50.00%	Abnormal	30.86%	Advanced
Image 4	0.0068	0.9099	0.9183	0.9966	83.33%	Abnormal	4.28%	Initial
Image 5	0.0176	0.7895	0.8992	0.9912	66.67%	Abnormal	6.01%	Initial
Image 6	0.0240	0.8896	0.7593	0.9880	83.33%	Abnormal	68.18%	Advanced
Image 7	0.0193	0.1869	0.9573	0.9904	83.33%	Normal	0.671	Healthy No leukemia
Image 8	0.0292	0.7385	0.8599	0.9854	83.33%	Abnormal	22.14	Advanced

Table 1: Table of GLCM Features with respect to different images.

Image Data	Image Label
	Image 1
	Image 2

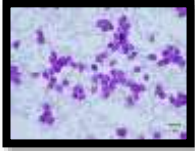

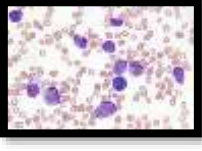



	Image 3
	Image 4
	Image 5
	Image 6
	Image 7
	Image 8

Table 2: Dataset along with respective label

Though we have worked with eight images, only four of them are displayed here.

Results of Image 1:-

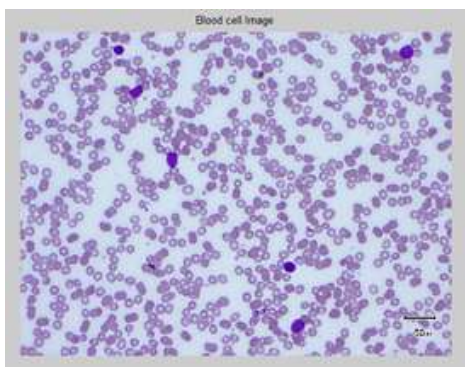


Figure 2: Original Image 1

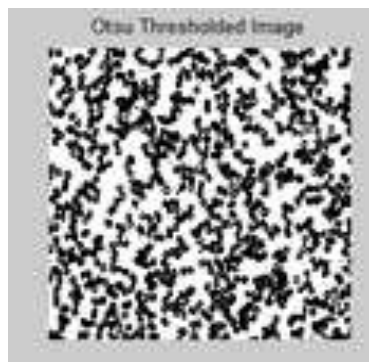


Figure 3: Otsu Thresholding of Image 1

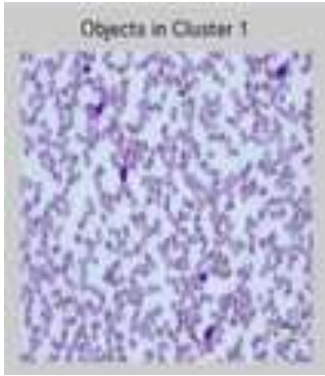


Figure 4: Creating a cluster for Image 1

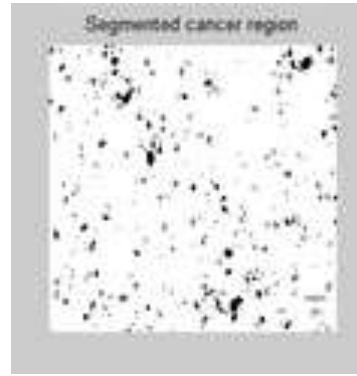


Figure 5: Segmenting the cancer region of Image 1

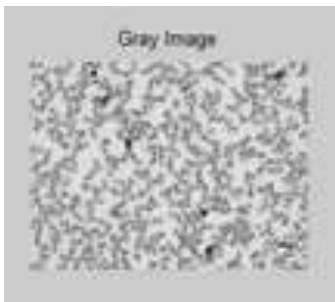


Figure 6: Grayscale Image of Image 1

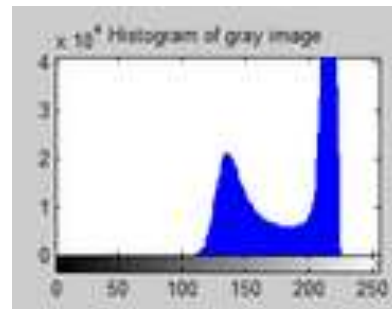


Figure 7: Histogram of Gray Image for Image 1

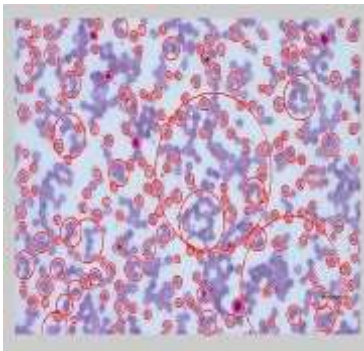


Figure 8: Detecting holes and infected areas of Image 1

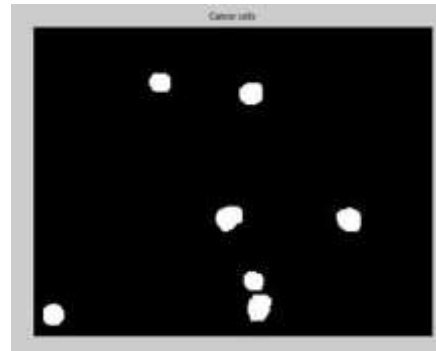


Figure 9: Binarization to extract cancer cells

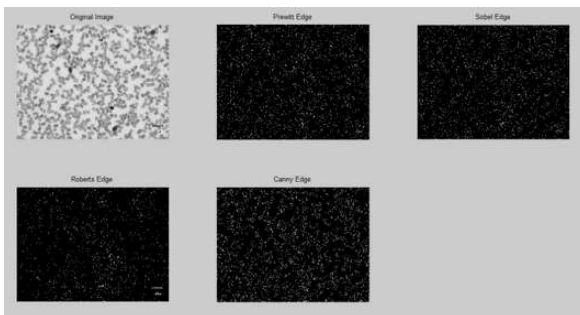


Figure 10: Edge detection of image 1



Figure 12: Determining the stage and myeloid cell of image 1

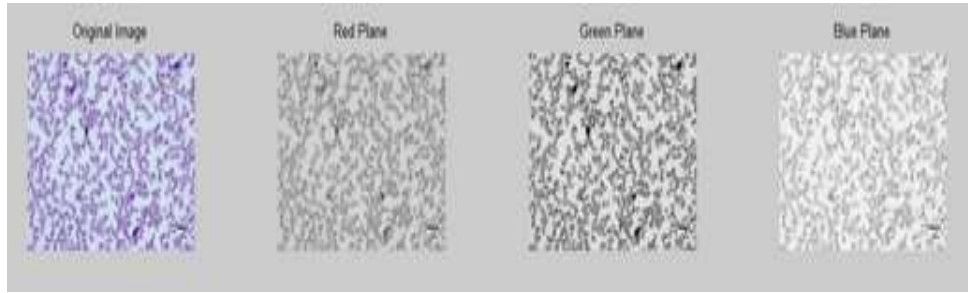


Figure 12: Plane slicing of image 1

Results of Image 2:-

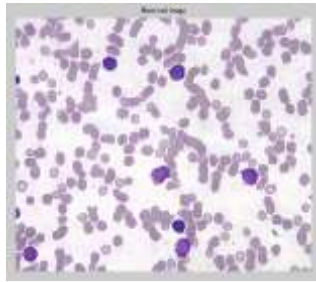


Figure 13: Original Image 2

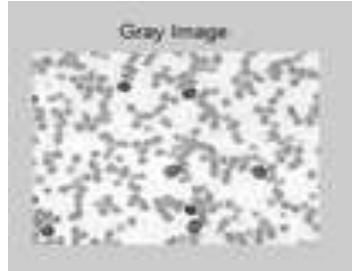


Figure 14: Grayscale Image of Image 2

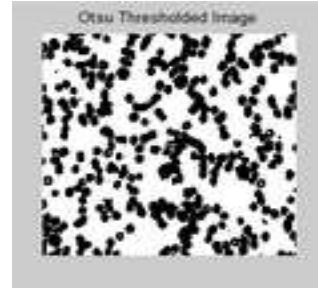


Figure 14: Otsu Thresholding of Image 2

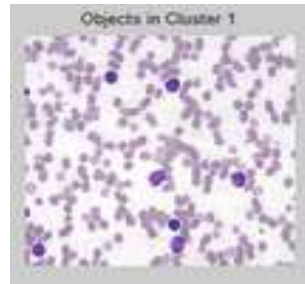


Figure 15: Creating a cluster for Image 2

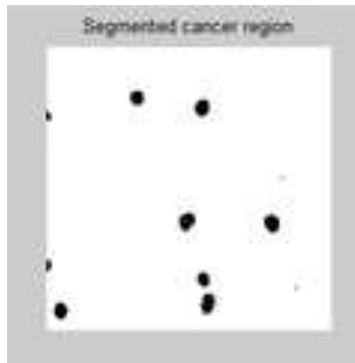


Figure 16: Segmenting the cancer region of Image 2

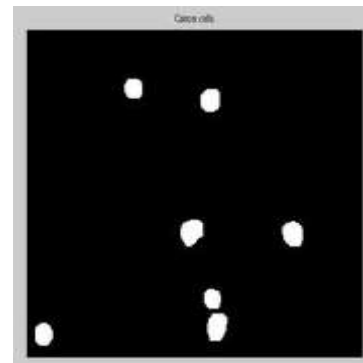


Figure 17: Binarization to extract cancer cells of Image 2

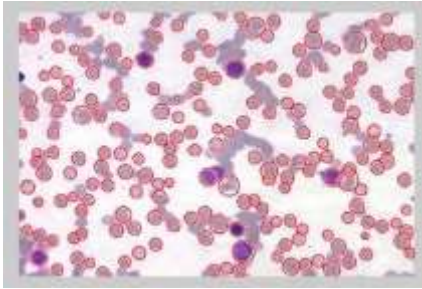


Figure 18: Detecting holes and infected areas of Image 2

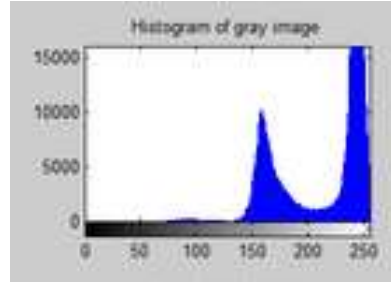


Figure 19: Histogram of gray image of Image 2

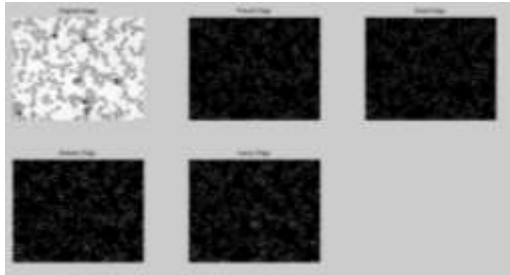


Figure 20: Edge detection of image 2

```
> In [initialization] at 117  
> In [contour] at 11  
Warning: The input image is already binary.  
> In [find] at 34  
> In [statistics] at 41  
Myeloid cells percentage is  
3.5314  
Initial Stage Leukemia  
In [ ]:
```

Figure 21: Determining the stage and myeloid cell of image 2

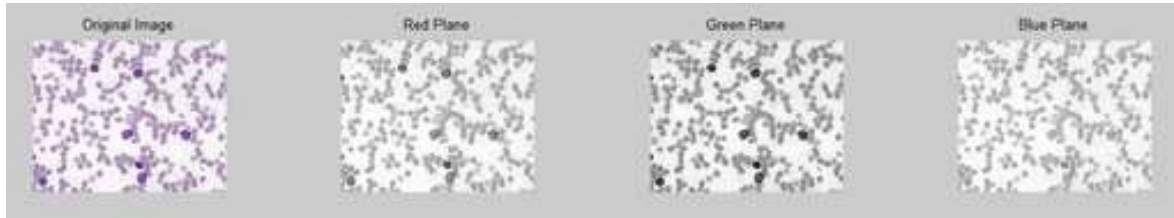


Figure 22: Plane slicing of image 2

Results of Image 3:-

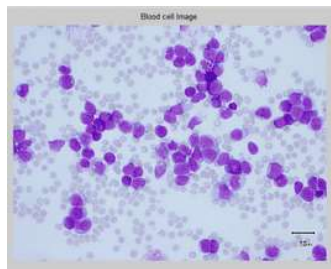


Figure 23: Original Image 3

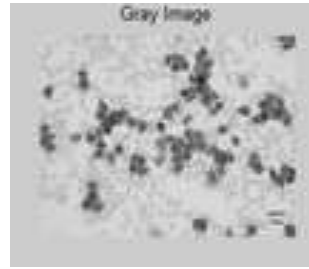


Figure 24: Grayscale Image of Image 3

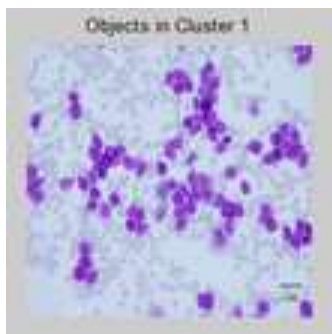


Figure 25: Creating a cluster for Image 3

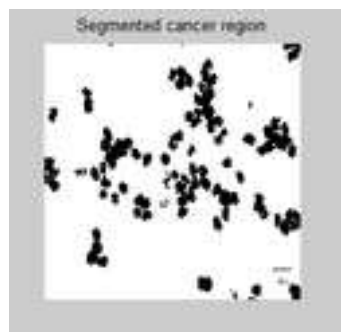


Figure 26: Segmenting the cancer region of Image 3

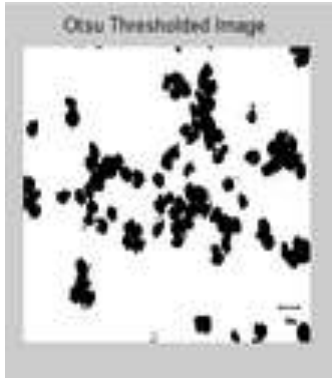


Figure 27: Otsu Thresholding of Image 3

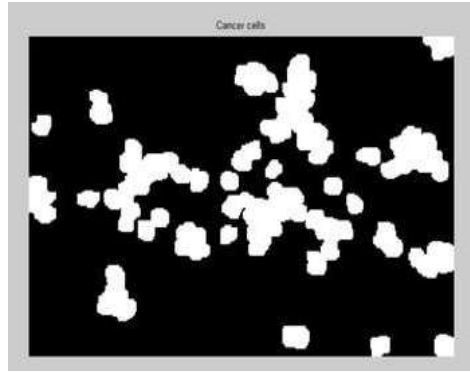


Figure 28: Binarization to extract cancer cells of Image 3

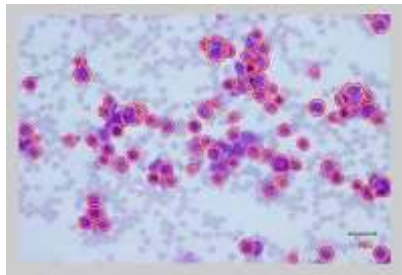


Figure 29: Detecting holes and infected areas of Image 3



Figure 30: Determining the stage and myeloid cell of image 3

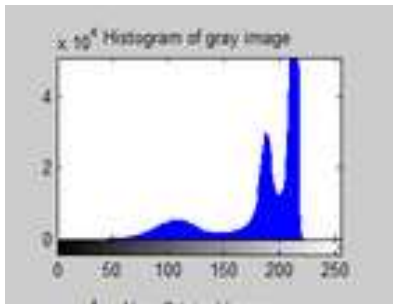


Figure 31: Determining the histogram of image 3

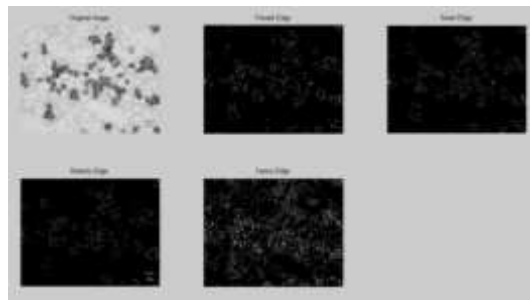


Figure 31: Edge detection of image 3

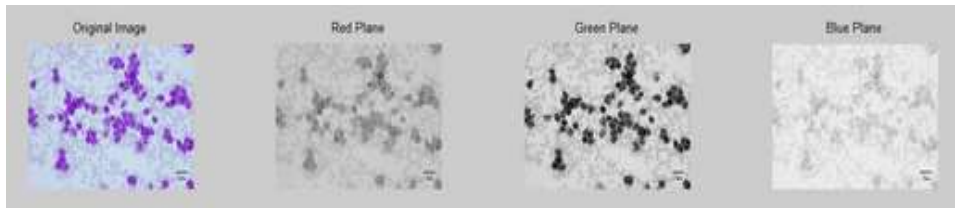


Figure 32: Plane slicing of image 3

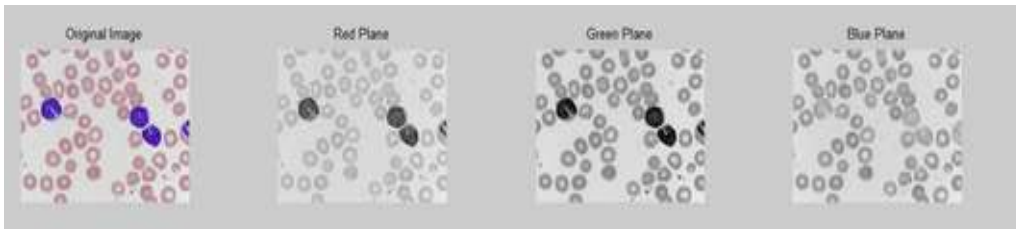


Figure 43: Plane slicing of image 4

VI. Conclusion:

Thus it can be concluded that this study uses nucleus segmentation and feature extraction mainly to predict the stage of Leukemia and express the percentage of myeloid cells for further application of diagnostic technologies. Area, perimeter, and other shape characteristics followed by histogram computation are taken into account for improved detection accuracy. The findings demonstrate that the suggested statistical parameters, including plane segmentation, edge detection, and Otsu thresholding achieved a good result.

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