PREDICTING PRESENCE OF LEUKEMIA CELLS IN BONE MARROW SAMPLES

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ABSTRACT

Blood cancers such as Leukemia and Myeloma originate in the bone marrow or lymphatic tissue. They are characterized by the appearance of immature, abnormal cells in the bone marrow and peripheral blood frequently in the liver, spleen and lymph nodes. The visual analysis of peripheral blood samples is an important test in the procedures for the diagnosis of leukemia. Our paper describes a preliminary study of developing a detection of leukemia types using microscopic blood sample images. Analyzing through images is very important as diseases can be detected and diagnosed at an earlier stage. For making the cells more prominent, we process the image by performing noise reduction, color segmentation, feature extraction, and classification, to detect blasts. Further we use simple morphological techniques such as, edge detection, gap filling, erosion and dilation to enhance the cell boundary and confirm presence of malignant leukemia cells.

Key Words: Leukemia, Lymphatic tissue, Color Segmentation, Feature extraction, Morphological techniques, Malignant.

INTRODUCTION

Leukemia is a common malignancy of white blood cells, specifically emerging fromLymphocytes. Our aim is to create an automated system which can predict the presence of lymphoblasts amongst white blood cells in a bone marrow sample. The main objective is to reduce human intervension in the process of predicting the malignancy of lymphocytes, by using simple image processing techniques such as noise reduction, color segmentation, feature extration and morphological techniques. These techniques make the image easier to process by improving its quality and extracting useful components by eleminating prtions of the image.

Proposed Procedure for Detection of Leukemia - Since lymphoblasts are characterized by shape, size and geometric structure, our system performs operations which extract required features from given samples and allows medical experts to analyse the sample in a manner such that only the cells in questions are depicted in the output. This process can be used to decrease manual processing which saves time and reduce error caused due to the same. The code can be modified for different color of cells in given samples and even for different geometric shapes. Even the amount of noise correction can be modified as required.This automated system is implemented in MATLAB, so it just requires a bone marrow sample image. This image is processed in two phases, in which , the first phase performs operations to demarcate the portion of the entire sample which contains lymphocytes. The second phase processes this lymphocyte and highlights its outer structure for further processing. Finally the

border of lymphocyte is analysed by morphological operations, and if boundary of the cell is not classified according to any geometrical feature like a circle or oval, its considered as a lymphoblast or malignant lymphocyte.

Our system focuses at reducing the error in leukemia prediction due to manual processing of the sample by making portions of the sample more prominent so that the cells can be analysed in an organised fashion. Step by step processing the samples enhances the lymphocytes which allow the medical expert in making an informed decision with the facts at hand.
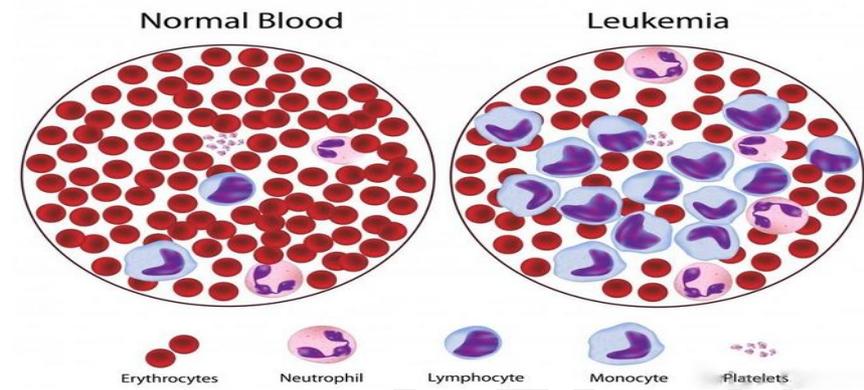

Fig 1 Blood Cell Sample

FUNDAMENTAL STEPS IN IMAGE PROCESSING
Image Acquisition: Acquiring an image in digital form.

Image Enhancement: Manipulating an image so that the result is more suitable than theoriginal image.

Image Restoration: Reversing the damage done to an image by a known operation.

Image Compression: Minimising the size of an image without degrading the quality of the image to an unacceptable level to coserve memory.

Image Segmentation: Partitioning a digital image into multiple segments to make the image more meaningful and easier to analiyse.

Colour Image Processing: Adding color to greyscale image so as to improve decription of the image and better human perception.

DETECTION OF LYMPHOCYTES AND LYMPHOBLASTS
Lymphocyte is a type of white blood cell present in the bone marrow. A lymphoblast is a different form of a naive lymphocyte that occurs when the lymphocyte is activated by an antigen and increased in volume by nucleus and cytoplasm growth as well as new mRNA and protein synthesis. The lymphoblast then starts dividing and making clones of its original naive cells.Usually, an automatic method for the detection of lymphoblasts in microscopically color images can be divided in the sequent steps.

Segmentation - the cells are separated from the back- ground by using algorithms based on different characteristics of the cells (e.g. shape, color, inner intensity).

Identification of white cells - the cells are classified in white cells and red cells. The classifiers can search the presence of the nucleus by using color information.

Identification of lymphocytes - the lymphocytes can be distinguished from the other white cells by analyzing the shape of the nucleus (e.g., a deeply staining nucleus which may be eccentric in location, and a small amount of cytoplasm).

Identification of candidate lymphoblasts - candidate lymphoblasts can be identified in a set of lymphocytes by the analysis of morphological deformations of the cell.

In particular, lymphocytes present a regular shape, and a compact nucleus with regular and continuous edges. Instead, lymphoblasts present shape irregularities.

DESIGN

The design of this project is very cost effective due to the use of basic methods like clustering segmentation, Sobel operator for edge detection and morphological methods such as erosion and dilation for smoothening. All these methods are low cost and simple and give us the desired output if applied in the correct sequence and in the correct way with appropriate parameters. Initially we discuss the fudamental steps for making the image more suitable for human perception and comprehention.

Once we get a more detailed and descriptive image, we perform a set of operations on the image so as to predict the presence of Lymphoblasts in the collection of cells in our given sample and we try to extract that cell using morphological methods. We perform processes such as scaling, noise correction, thresholding, edge detection, geometric feature extraction, feature identification, etc.
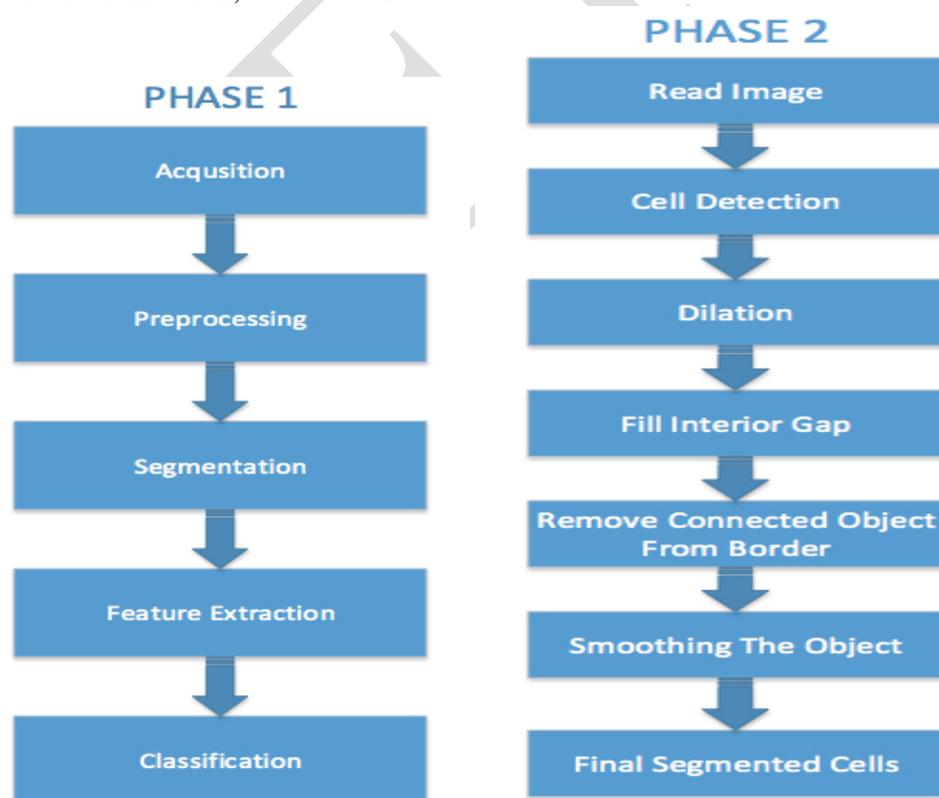

Fig 2. Implementation Phase 1   Fig 3. Implementation Phase 2

The output of Phase 1 provides us with a specific area of our initial sample in which we presume that the malignant cell resides. So, Phase 2 operations are focussed on processing the selected call and determining whether it is actually malignant or not. This is done by observing the cell boundary closely to observe its shape. If the shape coincides with any geometric feature (circular, oval, etc) we deduce that the cell is not infectious. On the other hand, if the cell boundary doesn't coincide with any geometric figure, it may be inferred that the cell is malignant and the patient requires immediate treatment.

METHODOLOGY:
Phase 1

1. Acquisition

Blood image from slides will be obtained with effective magnification.

2. Preprocessing

During image acquisition and excessive staining, the images will be disturbed by noise. The noise may be due to illumination or shadows that make region of interest (ROI) appear as blurred image region. Background will be excluded since our ROI will be white blood cells. During this preprocess, image enhancement will be done, as the contrast enhancement technique is capable to improve the medical image quality.

3. Segmentation

Segmentation of white blood cell (WBC) and determination of ROI, which is nucleus for WBC only. This is done because in leukemia cell images, the cytoplasm is scanty. So, focus will be on nucleus of WBC only. Determination the types of WBC should be done from the nucleus. Only lymphocytes and myelocytes should be considered and need to determine them whether they are blast cells or not. Once the blast cells are determined, then proceed to the next step. Sub images containing nucleus only will be considered. This is to reduce errors since there are similar color scales in WBCs with other blood particles.

4. Feature Extraction

The most important problem in generation of features of blood cells that characterize them in a way enabling the recognition of different blast types with the highest accuracy. The features to be used are for nucleus of lymphocytes and myelocytes:Geometrical Features – which includes area, radius, perimeter, symmetry, concavity, compactness, solidity, eccentricity, elongation, form factor will be obtained. Texture Features – which includes homogeneity, energy, correlation, entropy, contrast and angular second momentum will be obtained.Color Features – the RGB color spaces will be transformed into HSV or L*a*b color spaces. Their mean color values will be obtained.Statistical Features – the mean value, variance, skewness, kurtosis of the histograms of the image matrix and the gradient matrix for RGB or HSV or L*a*b color space (whichever appropriate) will be obtained.

5. Classification

The suitable recognition of leukemia cells requires the definition of good descriptive features that facilitate their classification. In this phase geometric feature is been extracted, and statistical, texture, and size ratio features from regions obtained in the segmentation process (nucleus, cytoplasm, and whole cell) and analyzed these features to identify types and subtypes of acute leukemia.

Phase 2

6. Read Cell Image

From bone marrow sample image, read area specific to lymphoblasts and define area to be processed further.

7. Detect Cell To Be Processed

Two cells are present in this image, but only one cell can be seen in its entirety. We will detect this cell. Another word for object detection is segmentation. The object to be segmented differs greatly in contrast from the background image. Changes in contrast can be detected by operators that calculate the gradient of an image. One way to calculate the gradient of an image is the Sobel operator, which creates a binary mask using a user-specified threshold value.

8. Dilate The Image

The binary gradient mask is dilated using the vertical structuring element followed by the horizontal structuring element. Dilation simply replicates positive intensities on the border to form softened image.

9. Fill Interior Gaps

The dilated gradient mask shows the outline of the cell quite nicely, but there are still holes in the interior of the cell. To fill these holes we use the imfill function and get the image

10. Remove Connected Objects From Border

The cell of interest has been successfully segmented, but it is not the only object that has been found. Any objects that are connected to the border of the image can be removed using the imclearborder function.

11. Smoothen The Object

Finally in order to make the segmented object look natural, eroding the image twice by a diamond shaped structuring element does smoothening, using strel function.

12. Final Segmented Image

A method for displaying the segmented object would be to place an outline around the segmented cell. The outline is created by bwperim function.
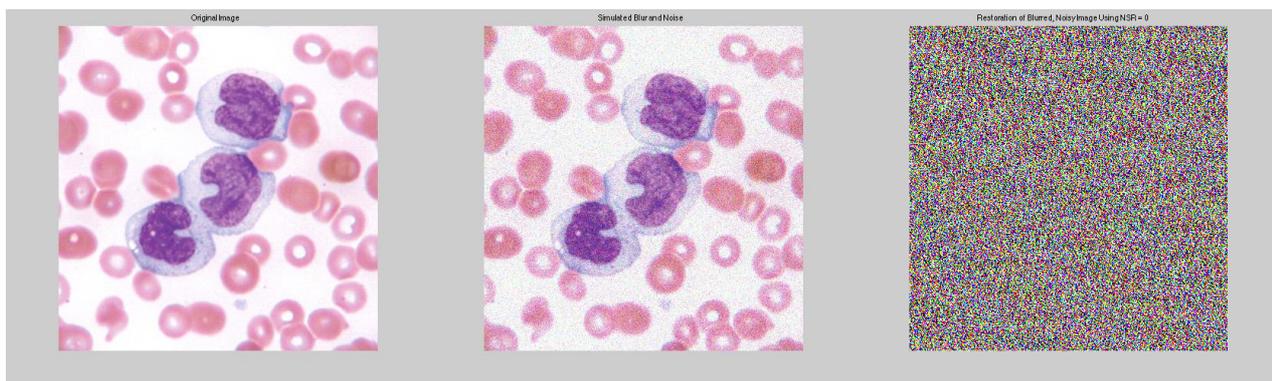
PHASE 1

Fig 7.Original image   Fig 8.Noisy image   Fig 9.NSR=0 Correction
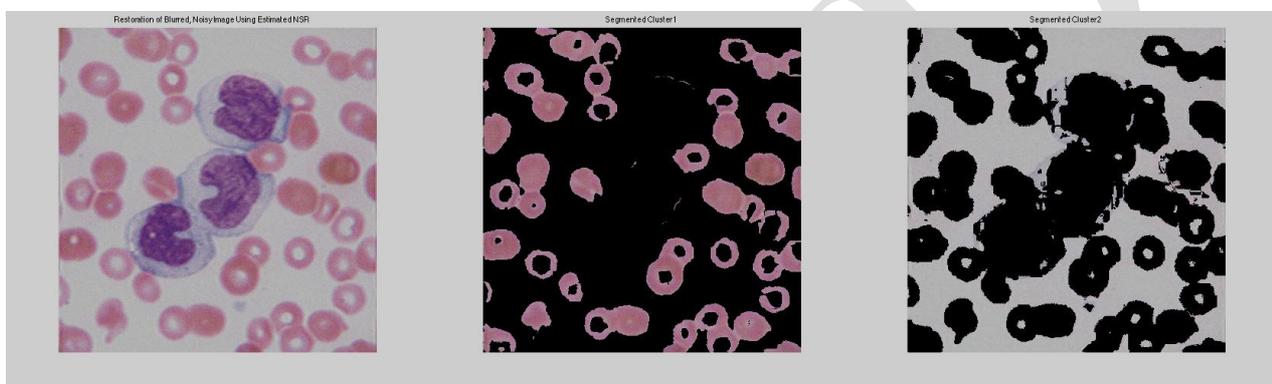
Fig 10.Noise Corrected   Fig 11.Segmented cluster 1   Fig 12.Segmented cluster 2
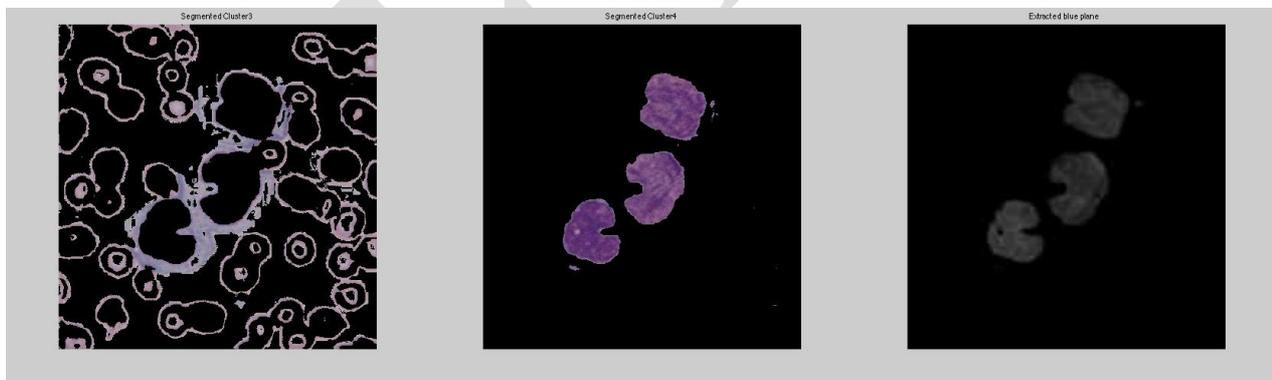
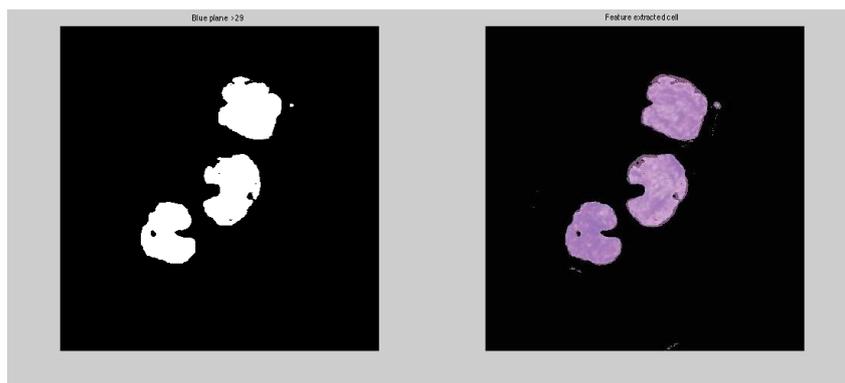Fig 13.Segmented cluster 3   Fig 14.Segmented cluster 4   Fig 15.Removing blue plane

Fig 16.Removing blue<29   Fig 17.Cell extracted image (Input to phase 2)

PHASE 2
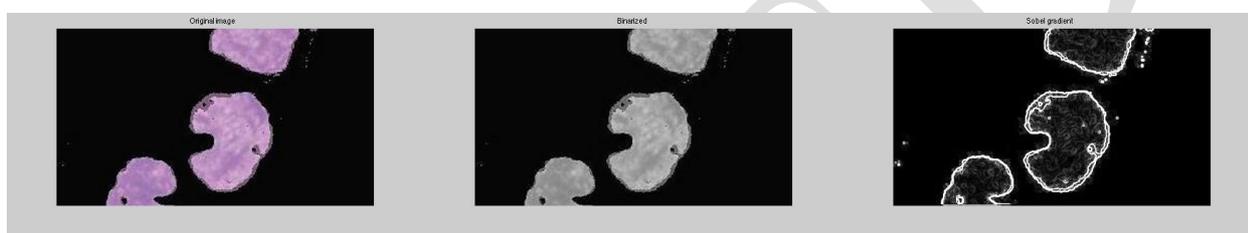

Fig 18.Input to phase 2   Fig 19.Binarised   Fig 20.Edge detected
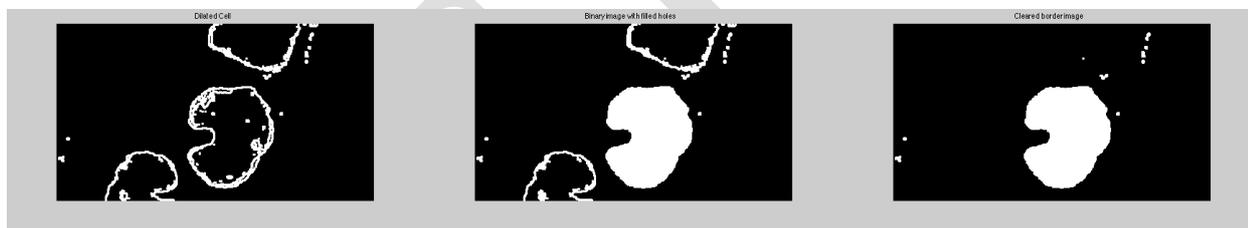

Fig 21.Dilated image   Fig 22.Boundary filled   Fig 23.Boundary eliminated

Fig 24.Eroded image   Fig 25.Highlighted centre Lymphoblast

CONCLUSION:

Thus using image-processing segmentation, edge of the cancerous blood cell can be obtained. MATLAB programming is used efficiently involving the concepts of image segmentation to give the required edge to be checked or any abnormal shape, which assures cancer in a

patient. This image in which edge of cancerous cell is obtained can be processed further for exact detection of cancer by any artificial intelligence technique.

REFERENCES:

[1] Fauziah Kasmin, Anton Satria Prabuwono, Azizi Abdullah, "Detection Of Leukemia in Human Blood Sample Based on Microscopis Images: A Study," Journal Of Theoretical and Applied Information Technology, vol. 46 no 2, 2012.

[2] Ruggero Donida Labati, Vincenzo Piuri, Fabio Scotti, "The Acute Lymphoblastic Leukemia Image Database for Image Processing," Universita Degli Studi Di Milano, 10.1109/ICIP.2011.6115881, 2011.

[3] S.Jagadeesh, Dr. E.Nagabhooshanam, Dr. S.Venkatachalam, "Image Processing Based Approach to Cancer Cell Prediction in Blood Samples, "International Journal of Technology and Engineering Sciences, vol.1, ISSN: 2320-8007, 2013.