DETECTION OF ACUTE LEUKEMIA USING WHITE BLOOD CELLS SEGMENTATION BASED ON BLOOD SAMPLES

Ms. Minal D. Joshi¹, Prof. A.H. Karode²
¹Department of E&TC, SSBT College of Engineering, NMU University, Jalgaon
²Department of E&TC, SSBT College of Engineering, NMU University, Jalgaon

ABSTRACT

In order to improve patient diagnosis various image processing software are developed to extract useful information from medical images. An essential part of the diagnosis and treatment of leukemia is the visual examination of the patient’s peripheral blood smear under the microscope. Morphological changes in the white blood cells are commonly used to determine the nature of the malignant cells, namely blasts. Morphological analysis of blood slides are influenced by factors such as hematologists experience and tiredness, resulting in non standardized reports. So there is always a need for a cost effective and robust automated system for leukemia screening which can greatly improve the output without being influenced by operator fatigue. This paper presents an application of image segmentation, feature extraction, selection and cell classification to the recognition and differentiation of normal cell from the blast cell. The system is applied for 108 images available in public image dataset for the study of leukemia. The methodology demonstrates that the application of pattern recognition is a powerful tool for the differentiation of normal cell and blast cell leading to the improvement in the early effective treatment for leukemia.

Keywords: Acute Lymphoblastic Leukemia (ALL), WBC segmentation, Public image dataset, Feature extraction, kNN classifier.

1. INTRODUCTION

Leukemia is a group of hematological neoplasia which usually affects blood, bone marrow, and lymph nodes. It is characterized by proliferation of abnormal white blood cells (leukocytes) in the bone marrow without responding to cell growth inhibitors [1]. Acute leukemia is classified according to the French-American-British (FAB) classification into
two types: Acute Lymphoblastic Leukemia (ALL) and Acute Myelogenous Leukemia (AML). In acute leukemia disease, cells that are not fully differentiated get affected. ALL is most common in children while AML mainly affects adults but can occur in children and adolescents. In this paper the main focus is on ALL. The early and fast identification of the leukemia type, greatly aids in providing the appropriate treatment for the particular type. Its detection starts with a complete blood count (CBC) [2]. If the count is abnormal, the patient is suggested to perform bone marrow biopsy. Therefore, to confirm the presence of leukemic cells, a study of morphological bone marrow and peripheral blood slide analysis is done. Manual examination of the slides are subjected to bias i.e. operator experience, tiredness etc. resulting with inconsistent and subjective reports. This paper represents blood slide image segmentation and classification for automatic detection of leukemia. For study purpose a public supervised image datasets (ALL-IDB) [3] is provided by Fabio Scotti to test and fairly compare algorithms for cell segmentation and classification of the ALL disease.

![Fig.1 The proposed system](image)

The proposed system for ALL detection is shown in Fig 1. It consists of various functional modules [4]. The input image of blood slide is fed to the system. As the blood contains various elements only WBCs are separated using segmentation. White blood cells fall into five categories: Neutrophil, Eosinophil, Basophil, Monocyte and Lymphocyte. Lymphocytes are responsible for ALL. Hence lymphocytes are detected and their features such as area, perimeter, circularity etc. are calculated using feature extraction module. Using these extracted features, classifier classifies the normal cell and blast cell. The most common method adopted for leukemia classification is the FAB method [3].

The segmentation step is very crucial because the accuracy of the subsequent feature extraction and classification depends on the correct segmentation of white blood cells. It is also a difficult and challenging problem due to the complex nature of the cells and uncertainty in the microscopic image. Many researchers have given different methods for image segmentation. Cseke used automatic thresholding method (1979). Threshold techniques cannot always produce meaningful results since no spatial information is used
during the selection of the segmentation threshold [5]. Edge detection method can also be meaningful for segmentation but it is applicable only when there is good contrast between foreground and background. (Piuri and Scotti) [6]. The K-Mean clustering method is utilized by Sinha and Ramakrishnan. However, the method of cropping the entire cell in order to get the real area of the whole cell is not clearly shown [7]. Theera-Umpon used a fuzzy C-Mean clustering to segment single cell images of white blood cells in the bone marrow into two regions, i.e., nucleus and non-nucleus. The computational time increases if the clusters number is greater than 2 [8].

2. IMAGE SEGMENTATION

This section shows steps of the image segmentation algorithm used in this system [9].

1) Input the colour blood slide image to the system.
2) Convert the colour image into grayscale image.
3) Enhance contrast of the grayscale image by histogram equalization method (A).
4) To adjust image intensity level apply linear contrast stretching to gray scale image (B).
5) Obtain the image I1=B+A to brighten all other image components except cell nucleus.
6) Obtain the image I2=I1-A to highlight the entire image objects along with cell nucleus.
7) Obtain the image I3=I1+I2 to remove all other components of blood with minimum effect of distortion over nucleus.
8) To reduce noise, preserve edges and increase the darkness of the nuclei implement 3-by-3 minimums filter on the image I3.
9) Apply a global threshold Otsu’s method on image I3 to get image I4.
10) Using the threshold value in above step convert I3 to binary image.
11) To remove small pixel groups use morphological opening.
12) To form objects connect the neighboring pixels.
13) By applying the size test removal of all objects that are less than 50% of average RBC area is done.

It is observed that this method of segmentation yields better results than that of previous methods.

3. FEATURE EXTRACTION

Feature extraction means to transfer the input data into different set of features. In this paper three features of lymphocyte cells have been observed viz. area, perimeter and circularity because shape of the nucleus is important feature for differentiation of blasts.

1) Area: The area was determined by counting the total number of none zero pixels within the image region.
2) Perimeter: It was measured by calculating distance between successive boundary pixels.
3) Circularity: This is a dimensionless parameter which changes with surface irregularities and is defined in equation (1):

\[ \text{Circularity} = \frac{4 \times \pi \times \text{Area}}{\text{Perimeter}^2} \] \hspace{1cm} (1)
4. CLASSIFICATION

Based on the features extracted in above steps classifier classifies the lymphocyte cells as blast or normal cells. The K-nearest neighbor (kNN) decision rule has been a ubiquitous classification tool with good scalability. In this system kNN classifier of k=1 is utilized.

5. EXPERIMENTAL RESULTS

The proposed technique has been applied on 108 peripheral blood smear images obtained from the public dataset as mentioned earlier. A microscopic blood image of size $2592 \times 1944$ is considered for evaluation [3]. The results of segmentation steps have shown below.

![Original image](image1) ![Gray scale image](image2) ![Histogram equalized image A](image3) ![Linear contrast stretched image B](image4)

Fig.2: a) Original image b) Gray scale image c) Histogram equalized image A d) Linear contrast stretched image B

In this paper Otsu’s method of segmentation is utilized along with image arithmetic. Fig. 2 shows the image histogram equalization and linear contrast stretching method results. After this step simple arithmetic operations are used along with Global thresholding method to detect white blood cell nucleus as shown in fig. 3.
After image arithmetic operation, minimum filter is applied to remove noise. Finally WBCs are shown with white spots all around its nucleus. This execution requires time period of millisecond. And in the last stage, using kNN classifier, normal lymphocytes and blast lymphocytes are classified. Fig. 4 shows the resultant images.

6. CONCLUSION

A WBC nucleus segmentation of stained blood smear images followed by relevant feature extraction for leukemia detection is the main theme of the paper. The paper mostly concentrates on measuring area, circularity, perimeter etc. features for better detection accuracy. Leukemia detection with the proposed features were classified with kNN classifier. The system is applied on 108 images from public dataset giving accuracy of 93%. Furthermore the system should be robust to excessive staining and touching cells.
REFERENCES

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