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Image Analysis Framework for Automatic Extraction of the Progress of an Infection

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Abstract— Analyzing the images refers to the extraction of meaningful information from images. Medical image analysis is one of the most critical studies in field of medicine, since results gained by the analysis, guide pathologists, radiologists, hematologists and oncologists for diagnosis, treatment planning, and verification of administered treatment. Therefore, accuracy in analysis of medical images is very important in order to detect an infection and a type of diseases. Also early diagnosis of the disease is fundamental for the recovery of patients especially in the case of diseases that often spreads quickly, like Leukemia. Leukemia is a type of blood cancer that starts in cells that form new blood cells. In particular, this image analysis framework shows the effectiveness of an automatic morphological method to identify the Acute Lymphocytic Leukemia by peripheral blood microscope images. The proposed system firstly individuates in the blood image the white blood cells from the others blood cells, then it select the lymphocyte cells (the ones interested by acute leukemia), and finally it classifies the presence of the leukemia. For this task the Otsu's global thresholding method is used to automatically perform histogram shape-based image thresholding or you can say the reduction of a gray level image to a binary image. The experimental results are compared with the manual results obtained by standard data set and demonstrate the efficiency of the proposed method. The performance analysis is done and the accuracy is reached up to the 93.6364% in calculation of the area, circularity and perimeter of the nucleus of the lymphocytes present in the microscopic images of blood samples.

Keywords— Medical image analysis, Leukemia, Acute Lymphocytic Leukemia, Lymphocyte, Nucleus.

I. INTRODUCTION

Acute Lymphocytic Leukemia (ALL) is incurable if left untreated due to its rapid spread into the bloodstream and other vital organs and it mainly affects young children and adults over 50. Early diagnosis of the disease is crucial for the recovery of patients especially in the case of children. The symptoms of ALL are common also in other disease and for this reason, the diagnosis is very difficult. One of the steps in the diagnostic procedures encompasses the microscope inspection of peripheral blood. The inspection consists on the research of white cells with abnormality due to the presence of a cancer. From decades, this operation is performed by experienced operators, which basically perform two main analyses: the cell classification and counting (now performed by cytometers). This analysis suffers from slowness and it presents a not standardized accuracy since it depends on the operator's capabilities and tiredness. Interestingly, the morphological analysis just requires an image, not a blood sample and hence is suitable for low-cost, standard-accurate, and remote screening systems [2]. The system proposed here firstly individuates in the blood image the white blood cells (WBC) from the others blood elements, then it extract the lymphocyte cells (the ones interested by acute leukemia), finally it classifies the presence of the leukemia. Leukocytes count is used to determine the presence of an infection in the human body Peripheral blood is an important component of the body's overall immunity that defends against infectious diseases and foreign substances. The WBCs in the peripheral blood are classified according to the size and shape of the nuclei and percentage ratio of nuclei to cytoplasm, including neutrophils, eosinophils, basophils, monocytes, and lymphocytes, as shown in Figure 1.

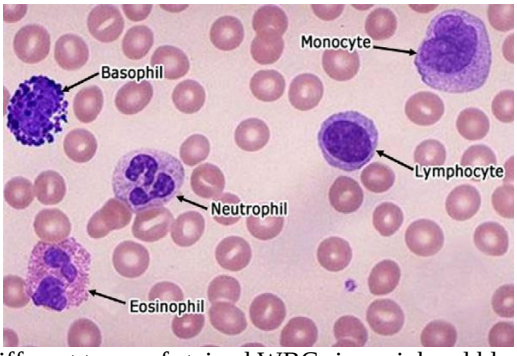

Fig 1: Five different types of stained WBCs in peripheral blood image [2].

The remainder of this paper is organized as follows. In Section 2, literature review is presented. In section 3, the methodology explained. In Section 4, results obtained by the proposed framework are presented, and finally, conclusions are drawn in Section 5.

II. LITERATURE REVIEW

We have presented Medical Image Segmentation: A Review [1]. In this study, the overview of various segmentation methodologies applied for digital image processing is explained briefly. The study also reviews the research on various research methodologies applied for image segmentation and various research issues in this field of study. This study aims to provide a simple guide to the researcher for those carried out their research study in the image segmentation. In this paper we project the important place of segmentation of images in extracting information for decision making. [2] proposed an ALL-IDB: The Acute Lymphoblastic Leukemia Image Database for Image Processing. In it a new public dataset of blood samples, specifically designed for the evaluation and the comparison of algorithms for segmentation and classification. For each image in the dataset, the classification of cell is given, and it is provided a specific set of figures of merits to be processed in order to fairly compare different algorithms when working with the proposed dataset. P.S.Hiremath, P.Bannigidad and Sai Geeta [3] have proposed a color based segmentation method and the geometric features extracted for each segment are used to identify and classify the different types of white blood cells. The objective of the present study is to develop an automatic tool to identify and classify the white blood cells namely, lymphocytes, monocytes and neutrophil in digital microscopic images. C.Reta, L.Alamirano, J.A.Gonzales, R. Diaz,and J.S.Guichard [4] proposed the Segmentation of Bone Marrow for Morphological Classification of Acute Leukemia. In it they present a two phase methodology to analyze the morphology of abnormal leukocytes images for the classification of acute leukemia subtypes using image processing and data mining techniques. R. Adollah, M. Mashor, N. M. Nasir, H. Rosline, H. Mahsin, and H. Adilah [5] have proposed a review on Blood cell image segmentation. According to them Image processing technique involved five basic components which are image acquisition, image preprocessing, image segmentation, image post processing and image analysis. C. Di Rubeto, A. Dempster, S. Khan, and B. Jarra [6] proposed the Segmentation of blood images using morphological operators. This work describes a part of a malarial image processing system for detecting and classifying malaria parasites in images of Giemsa stained blood slides in order to evaluate the parasitaemia of the blood. A major requirement of the system is an efficient method to segment cell images. D. Anoraganingrum [7] proposed Cell segmentation with median filter and mathematical morphology operation, that describes a part of their research work on an Automated Cell Tracking (ACT) project with the aim of tracking the movement of representative cells in order to determine the activity of the cell once certain medical substances have been injected. A major requirement for their project is an efficient method to segment cell images.

J. Wu, P. Zeng, Y. Zhou, and C. Olivier [8] proposed a novel color image segmentation method and its application to white blood cell image analysis. According to the fact that the H component in HIS color space contains most of the white blood cell information, and the S component contains the structure information of the white blood cell nucleus, they developed an iterative Otsu's approach based on circular histogram for the leukocyte segmentation by taking full advantage of this knowledge. T. Mouroutis, S. J. Roberts, and A. A. Bharath, [9] proposed Robust cell nuclei segmentation using statistical modeling. In it they have proposed the multistage segmentation method for isolation of cell nuclei which is applicable to light microscope images of stained tissue sections. Fabio Scotti, [10] proposed an automatic morphological analysis for acute leukemia identification in peripheral blood microscope images. The presented paper shows the effectiveness of an automatic morphological method to identify the Acute Lymphocytic Leukemia by peripheral blood microscope images. Mostafa Mohamed and Amr Guaily [11] proposed an efficient technique for white blood cells nuclei automatic segmentation. The technique is based on gray scale contrast enhancement and filtering. Minimum segment size is implemented to remove false objects. The technique is tested on 365 blood images. The segmentation performance is quantitatively evaluated on the test set to be 79.7%.

III. METHODOLOGY

All The overview of various segmentation methodologies applied for digital image processing is explained briefly in the review paper [1]. The study also reviews the research on various research methodologies applied for image segmentation and various research issues in this field of study. This study aims to provide a simple guide to the researcher for those carried out their research study in the image segmentation. we have compared the various image segmentation techniques, according to them the image segmentation techniques includes thresholding method, clustering approach, region based approaches and edge detection approaches. Thresholding algorithms can be selected manually according to a priori knowledge or automatically by image information. These algorithms further divided to edge-based, region-based and hybrid.

Image segmentation by thresholding is a simple but powerful approach for segmenting images having light objects on dark background. Thresholding technique is based on imagespace regions i.e. on characteristics of image. Thresholding operation convert a multilevel image into a binary image i.e., it choose a proper threshold T, to divide image pixels into several regions and separate objects from background. Any pixel (x, y) is considered as a part of object if its intensity is greater than or equal to threshold value i.e., $f(x, y) \geq T$, else pixel belong to background. As per the selection of thresholding value, two types of thresholding methods are in existence, global and local thresholding. When T is constant, the approach is called global thresholding otherwise it is called local thresholding. Global thresholding methods can fail when the background illumination is uneven. In local thresholding, multiple thresholds are used to compensate for uneven illumination.

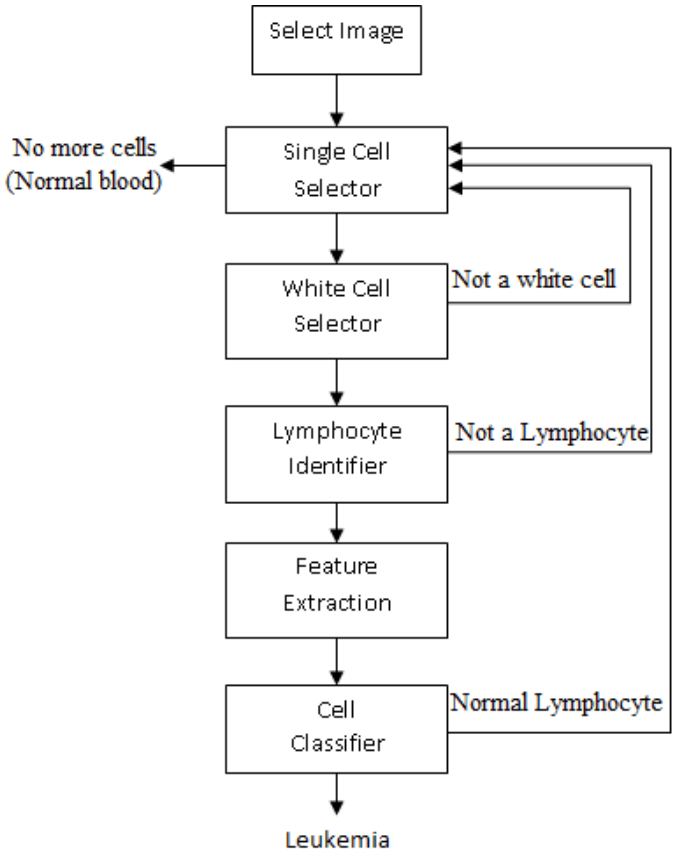

Fig. 2 Accute Leukemia Classification System [10].

System Design: The system we propose firstly individuates in the blood image the leucocytes from the others blood cells, then it extracts the lymphocyte cells (the ones interested by acute leukemia), it extracts morphological indexes from those cells and finally it classifies the presence of the leukemia. The main modules which compose the overall system are plotted in Figure 2. The Single-cell Selector module firstly enhances the input image and identifies the single cells. It has been composed by adaptive prefiltering and segmentation algorithms. Secondly, the White-cells Identifier module selects the white cells present into the image by separating them from others blood's components (red cells and platelets). The third module (the Lymphocyte Identifier) can recognize a lymphocyte with respect to the other selected white cells. The three presented modules can recognize leucocytes in a blood film image with an accuracy of about 93.6364%.

Data set: Automated systems based on artificial vision methods can speed up this operation and they can increase the accuracy of the response also in telemedicine applications. Unfortunately, there are not available public image datasets to test and compare such algorithms. In this project public dataset of blood samples is used, specifically designed for the evaluation and the comparison of algorithms for segmentation and classification [2]. For each image in the dataset, the classification of cell is given, and it is provided a specific set of figures of merits to be processed in order to fairly compare different algorithms when working with the proposed dataset. The annotation of ALL-IDB1 is as follows. The ALLIDB1

image files are named with the notation ImXXX Y.jpg where XXX is a 3-digit integer counter and Y is a Boolean digit equal to 0 is no blast cells are present, and equal to 1 if at least one blast cell is present in the image. Please note that all images labeled with Y=0 are from for healthy individuals, and all images labeled with Y=1 are from ALL patients.

IV. EXPERIMENTAL RESULTS

The proposed framework has been tested using sample microscopic images (standard database) from the 'Acute Lymphoblastic Leukemia Image Database for Image Processing', Department of Information Technology-Universita degli Studi di Milano. For each image in the dataset, the classification/position of ALL lymphoblast is provided by expert oncologists. The images of the dataset has been captured with an optical laboratory microscope coupled with a Canon Power Shot G5 camera. All images are in JPG format with 24 bit color depth, resolution 2592 x 1944. The dataset is composed of 108 images collected during September, 2005. It contains about 39000 blood elements, where the lymphocytes have been labeled by expert oncologists. The images are taken with different magnifications of the microscope ranging from 300 to 500. The input of leukocyte cell image is converted into grayscale image and then we perform histogram equalization and the morphological operations are applied. The resulting image is global thresholded to obtain segmented binary image. The segmented image is labeled and for each segmented region (known leukocyte cells), the geometric features are extracted. The system firstly selects a single image from the dataset (a), then it segment out the WBC showing white spots around the cell from the others blood cells (b), then it extracts the lymphocyte cells

(the ones interested by acute leukemia) (c), and finally it classifies the presence of the leukemia (d) that means lymphoblast. We tested 108 microscopic images from the standard database. Figure 3 shows (a), (b), (c) and (d) images as described above, for the selected three images from standard database.

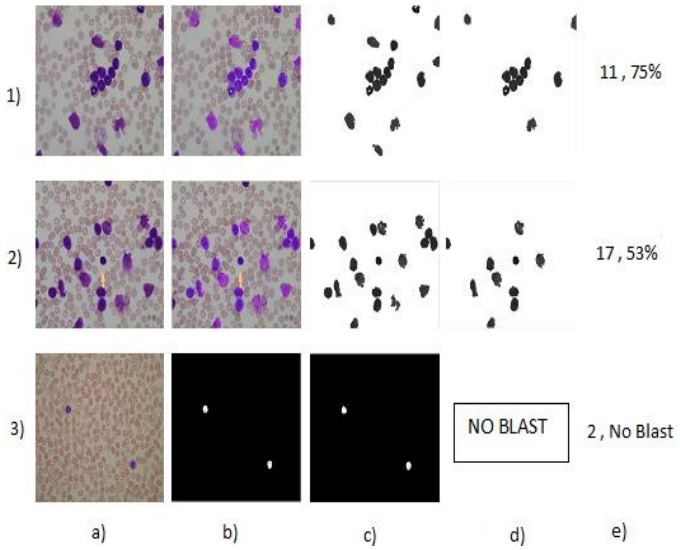

Fig. 3 Examples of the result

In above figure, the three samples of images are taken among which 1) ,2) leukemic samples, 3) healthy blood sample, (a) a single image from the dataset, (b) segmented WBC showing white spots around the cell from the others blood cells, (c) extracted lymphocyte cells (the ones interested by acute leukemia), and finally (d) classifies the presence of the leukemia that means lymphoblast, e) shows the No of WBCs and Percentage of blast.

Performance Evaluation: Performance evaluation, commonly known as the investigation of a program's behavior using information gathered as the program executes. Its goal is to determine which sections of a program to optimize. We have analyzed the performance of the system in order to calculate the accuracy in percentage. In order to measure and fairly compare the identification, accuracy of different structures of modules, we used the following bench marks [2]. Note that the test is positive if the considered image contains at least one blast cell or not.

True positives (TP) - the number of elements correctly classified as positive by the test;

True negatives (TN) - the number of elements correctly classified as negative by the test;

False positive (FP) - also known as type I error, is the number of elements classified as positive by the test, but they are not;

True positive (FN) - also known as type II error, is the number of elements classified as negative by the test, but they are not.

Using these definitions, it is possible to process the following standard parameters:

Sensitivity: the probability of correctly classifying elements with ALL equals to TP/ (TP + FN),

Specificity: the probability of correctly classifying elements without ALL computable as TN/ (TN + FP) and

Classification error: where the total error in an analysis layer is defined by CE = FP + FN.

The proposed system has reached successfully up to the accuracy of about 93.6364%.

V. CONCLUSIONS

In this study, we proposed an image analysis framework for automatic extraction of the progress of an infection to provide an alternative solution to the problem where white blood cell counting can be carried out automatically at low cost by designing an automated system. The experimental results are compared with the manual results obtained by standard data set. The proposed method is more reliable and computationally less expensive. We hope that the presented framework could help to give birth to new studies in this important field of research under a fair comparative approach.

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