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Application of Multiwavelet Transform in Determining Ratio of Blood Cells for Leukemia Detection

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Abstract- Fast and cost-effective generation of blood cell count reports are of paramount importance in the healthcare sector. The traditional method of manual counting under a microscope yields inaccurate results and put an intolerable amount of stress to medical laboratory technicians. In order to avoid high vulnerability in human error and large time consumption, better and more effective image processing software is needed. As a solution to this problem, this paper proposes an image processing technique for counting the number of blood cells. The blood cell count will then be used to calculate the ratio of blood cells for leukemia detection. For this purpose, few pre-processing and post-processing techniques have been implemented on blood cells image so as to achieve noise free image for blood cells ratio calculation. The results portray that the ratio of blood cells calculated using the proposed image processing techniques are able to differentiate between normal and abnormal blood cell image for leukemia detection.

Keywords- **Blood cells ratio calculation, Blood cells, image, Image processing, Leukemia, Multiwavelet Transform.**

I. INTRODUCTION

The importance of medical analysis and visualization can be recognized from the recent works in the medical imaging technologies like segmentation of kidney from ultrasound images, segmentation of brain images [1,2], locating of tumors and other pathologies [3]. Nowadays, there is a rapid change in the practice of detection of leukemia cells by using a complement-mediated cytolytic reaction and an imaging sensor system [4].

Leukemia is a disease that affects blood forming cells in the body. Its cancerous condition is characterized by an abundance of abnormal white blood cells in the body. Based on the research by M. D. Anderson Cancer Center, leukemia begins in the bone marrow and spreads to the other parts of the body [5]. In a healthy body, bone marrow makes white blood cells to help the body fight an infection. When a person has leukemia, the bone marrow starts to build a lot of abnormal white blood cells called leukemia cells. They grow faster than normal cells and they do not stop growing when they should.

According to Hany Ariffin, there are several types of leukemia, but the most commonly detected from the patients are Acute Lymphoblastic Leukemia (ALL) which involves 70% of the leukemia cases each year [6]. In 2009, it is estimated that approximately 31,490 individuals will be diagnosed with leukemia and 44,510 individuals will die of the disease in the United States [7]. Based on the high number of leukemia cases, the requirement for fast and cost-effective production of blood cell count reports is of paramount importance in the healthcare sector. Conventionally, manual counting under the microscope is one of the methods being used for blood cell counting. However, if the counting process is interrupted, it has to be started all over again from the beginning. Although machine such as the Automated Hematology Counter has been developed to automate the counting process, certain developing countries are not able to deploy such an expensive machine in every hospital laboratory in the country [9]. This paper proposes an alternative solution to this problem through cost-effective and efficient application in recognizing and analyzing blood cells.

This study involves the application of thresholding technique in determining ratio of blood cells for leukemia detection. The most important step in blood cell image processing is the cytological image segmentation and automatic counting. There are several general-purpose algorithms and techniques that have been developed for blood cells image segmentation [1,3]. By combining mathematical theories and computer vision, a much greater progress has been achieved in image segmentation. However, some algorithms for segmentation have their own drawbacks [10].

As for the blood cell images, due to the cells' complex nature and overlapping between them, it is still a challenging task to segment and count them [4]. These are two critical issues in image segmentation where the common segmentation algorithms are not able to solve the problem. Due to the blood cells' complex texture and unevenness of the gray level intensity, it is quite difficult to count and segment cell from its background automatically [4]. However, this can be done by thresholding technique. In this study, a new method of segmentation and ratio calculation of blood cells image is proposed.

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II. METHODOLOGY

The main objective of this study is to design and develop an image processing system for blood cell counting. Normally, the number of white blood cell in patients with positive cases of leukemia will increase. The increasing number of white blood cell will increase the ratio of white blood cell (WBC) to red blood cell (RBC). Thus, it is important to have a cost effective image processing system which will assist hematologists to determine the ratio of white blood cells to red blood cells for leukemia detection. The methodology used to develop the image processing system is described in the following sections.

A. Image Acquisition

A total of 21 data (each data/image consists of blood cells) were collected from the internet database [8]. The images of blood cell have been captured using computerized microscope. The captured images were revised by the hematologist to determine the appropriateness and type of the blood cell. The image analysis includes 14 images of Acute Lmphoblastic Leukemia (ALL) and 07 images of normal blood cells.

B. Development of Image Processing System for Ratio

Calculation Matlab 7.0 software has been used in this study to develop a system for blood cell ratio calculation. The main objective of using Matlab for this project is to provide a software solution which is cost effective as well as efficient for the developing and underdeveloped countries. The development of this system involved several stages. These include image pre-processing techniques which were conducted before the calculation on the blood cells ratio could be implemented on the blood cells image. Examples of image pre-processing techniques include grayscale image, binary image and image contrast enhancement. In this project, the method used to determine the ratio of blood cells is by counting the number of white blood cell (WBC) to red blood cell (RBC).

In this study, image processing system for blood cells calculation has been developed using two methods. The first method is shown in Fig. 1. By referring to this flow chart, the original blood cell image is firstly converted to grayscale image. Then, based on the grayscale image, the threshold values for the WBC and RBC are determined manually. These threshold values will be used to segment area of WBC and RBC by using the thresholding values. The image obtained from the segmentation process will be converted into binary image. If the result of these preprocessing techniques is satisfied, the binary image is used to ease blood cells ratio calculation.

The second proposed method is shown in Fig. 2. The image enhancement is done during the first stage before it can be converted into grayscale image. The purpose for enhancing the image is to obtain noise free image. Then, the rest of the steps are the same as in the first method.

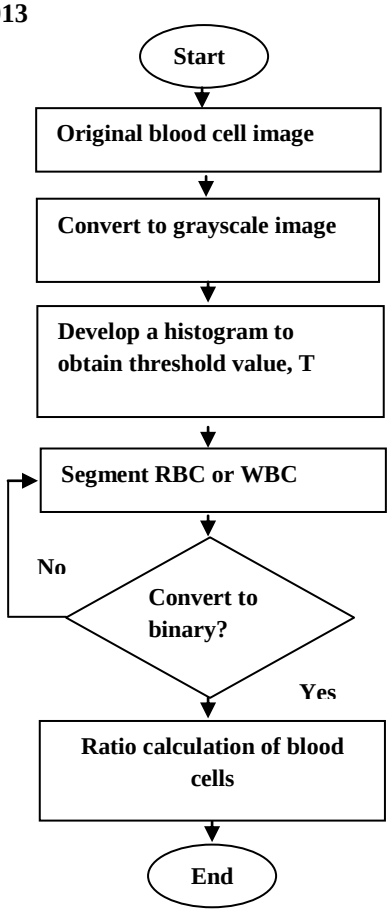

Fig. 1. Flow chart of the image processing system

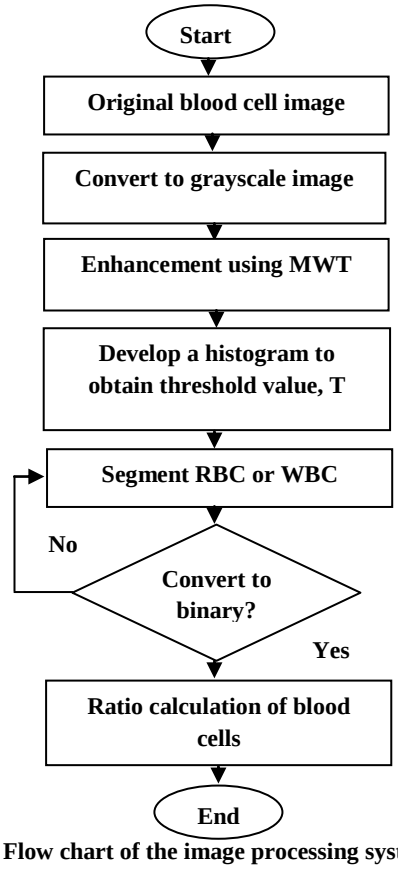

Fig. 2: Flow chart of the image processing system

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C. Image Pre-processing

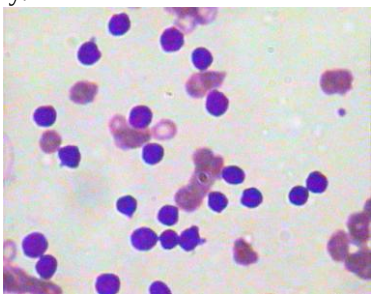
Pre-processing of an image involves image enhancement, obtaining grayscale image, and binary image in the development of this image processing system. In this study, the gray level histogram is important to distinguish between RBC, WBC and background areas. A threshold value in an image normally lies in the valley between the two peaks. In Matlab 7.0, the development of the histogram can be done by using the IMHIST function. Fig. 3(c) shows an example of gray level histogram for a blood cells image. The histogram is divided into 3 separate regions which include the WBC, RBC and the background indicated by (a), (b) and (c) respectively. Therefore, the valley value between peaks in region (a) and (b) is the threshold value in distinguishing between RBC and WBC while the valley value between peaks in region (b) and (c) is the threshold value in distinguishing between RBC and background region. These two threshold values will be used to segment region of interest (RBC or WBC) in the blood cell images.

Thresholding is a method of converting a grayscale image to a binary image so that the objects (WBC and RBC) are separated from the background [11]. Threshold value is applied on each image in order to obtain image with either RBC or WBC. Based on Fig. 3(c), we set the threshold into 3 regions; i) pixels value in the range of 0 to 89 were converted to 255 which represents the WBC, ii) pixels value in the range of 90 to 170 were converted to 255 which represents the RBC and iii) pixels value in the range of 171 to 255 were converted to 0 which represents the background.

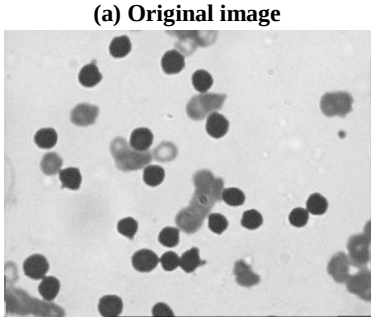
Binary images are images containing only two colors, black (0) and white (1 or 255). Binary images are formed by thresholding a grayscale or color image to segment region of interest of an object from unwanted areas [11]. In this study, the thresholding technique was implemented on the grayscale image to obtain binary image of WBC (WBC will be white in color while RBC and background areas will be black) and RBC (RBC will be white in color while WBC and background areas will be black). If the results were not satisfied, the pre-processing techniques will be repeated by determining the new threshold values.

Normally, the original binary image consists of small spots within the image. These small spots are assumed as noise and need to be removed from the image. Hence, we proposed multiwavelet transform de-noising method to obtain clear image. The output image of this stage is used to calculate the blood cells ratio for leukemia detection.

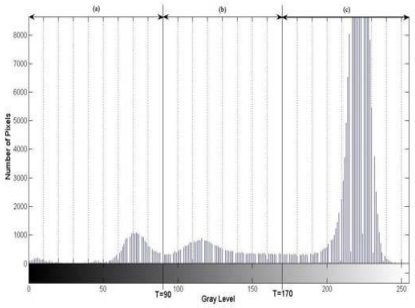
Counting the number of WBC and RBC from the samples is important in obtaining the ratio of WBC to RBC. First, the WBC number was determined and continued with the RBC number. The segmented blood cell image as in Fig. 3(d) and the function BWLABEL of Matlab 7.0 were used to count the number of cells automatically.



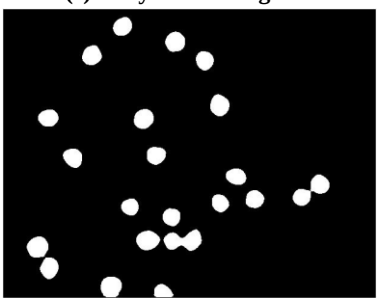
(a) Original image



(b) Grayscale image



(c) Gray level histogram



(d) Result of WBC in binary image

Fig. 3. Application of image processing system to Acute Lmphoblastic Leukemia (ALL) image.

III. RESULTS AND DISCUSSION

A. Image Pre-processing on Blood Cell Images

The two proposed method have been implemented on 21 blood cell images. From these 21 images, 07 images are normal blood cell and 14 images are abnormal blood cell. The results of the blood cells image pre-processing applied to the Acute Lmphoblastic Leukemia (ALL) image for blood cell counting are shown in Fig. 3.

Fig. 3(a) shows the captured Acute Lmphoblastic Leukemia (ALL) image at a resolution of 600 x 400. The

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grayscale image of ALL blood cell is shown in Fig. 3(b). Fig. 3(c) shows the gray level histogram. Based on Fig. 3(c), the histogram indicates sharp accent at certain points when traversing the histogram from left to right. Since the blood cell slides were stained with chemicals to enable the nucleolus of the white blood cells to take a unique color, the gray level intensity in WBC is darker compared to the RBC. The histogram is divided into 3 separate regions which include the WBC, RBC and the background indicated by (a), (b) and (c) respectively. The threshold value was selected manually and used to segment the WBC or RBC from the image background. After applying the thresholding method, the binary images of WBC and RBC for each blood cell images were obtained as shown in Fig. 3(d). Object pixels (WBC and RBC) will have the value of 1 and the background pixels will have the value of 0. Based from these binary images, there are small spots of object appearing in the WBC background images. This noise was removed to enhance the quality of the images in order to obtain the accurate number of WBC and RBC in blood cell counting. The blood plasma and dust particles in WBC images were cleaned by removing all object containing fewer than 100 pixels and applying the Gaussian filter, if needed.

B. Ratio Determination of Blood Cell Images

Fig. 4 shows the results for all 21 images. For each figure, the 2 types of images (normal and ALL) are shown by lines of blue and pink respectively. Fig. 4 shows the ratio of WBC to RBC which has been determined by applying the image enhancement techniques.

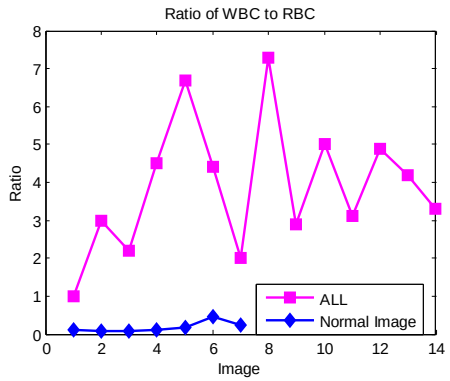

Fig. 4. The ratio of WBC to RBC for enhanced image

Overall the results show that the proposed methods are able to calculate the blood cell ratio. In Fig. 4 it is clearly seen that the ratio of WBC to RBC for normal image (shown by blue line) and abnormal image (shown by pink line for ALL) have different range of ratio. For the normal images, it can clearly be seen that ratio range for normal images is 0 to 0.4. This shows that the number of WBC is less than RBC. For abnormal images, the ratio range is 1 to 7 for ALL. These results show that the ratios for abnormal images (ALL) are obviously higher than the ratios for normal blood cells images. The results also show that the ratio of WBC and RBC is suitable and able to be used in leukemia detection.

IV. CONCLUSION

With the increasing number of leukemia cases worldwide, there is a need for fast and cost-effective production of blood cell count reports. This paper proposes an image processing system using Matlab software for blood cells counting for leukemia detection. The image processing system includes an effective and efficient method in recognizing and counting blood cells as a practical alternative to the manual blood cell counting. The blood cell ratios obtained are based on the image enhancement methods applied during the blood cells image pre-processing. The blood ratios calculation yields promising results in determining types of images (normal and abnormal blood cell images). This study is further extended by author in which individual blood cell image is decomposed to separate the segment of WBC to its two dominant elements: nucleus and cytoplasm, to assist hematologists in detection of leukemia.

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