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CONVEX HULL BASED WBC COMPUTATION FOR LEUKAEMIA DETECTION

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ABSTRACT: Detection of leukaemia in a patient is done by determining the abnormal white blood cell (WBC) count and calculating the blood cell ratio. Traditional method of finding the blood count of a suspected leukaemia patient employs manual counting of the cells using a microscope, which is prone to errors, is time consuming and stressful to the medical technicians. Image processing techniques can make this process more reliable and efficient. In this paper, image enhancement techniques have been applied on the blood sample image to obtain a better image for Blood Cell Ratio calculations. Convex hull of blood cells is computed to determine the number of cells in an image. Results show that the technique is able to give better results for counting number of WBC and computing Blood Cell Ratio**.**

Keywords: Leukaemia, White Blood Cells, Thresholding, Convex Hull, Blood Cell Ratio

I.INTRODUCTION

Medical imaging is becoming widely prevalent for diagnosis and analysis of a varied number of diseases. Techniques such as ultrasound are used for segmentation of the kidneys for location of tumours [1]. Magnetic resonance imaging (MRI) and echocardiography are other powerful methods of detecting abnormalities in the human body. Image processing techniques are now being extended for early and efficient detection of blood cancer or leukaemia.

Leukaemia is a disease which affects the blood forming cells. It results in the production of abnormal leucocytes or white blood cells (WBC) in a large amount. As the number of these cells increase, they hinder in the production of the red blood cells (RBC) and proliferate the bone marrow [2]. When the number of abnormal blood cells increases in the bone marrow, they overflow and enter the blood vessels, leading to transfer of these cells to other organs and causing multi-organ failure. The presence of large number of white blood cells can help in diagnosis of leukaemia.

Conventional methods use manual counting of the blood cells from the blood smear of the patient. This method is very slow. Moreover, the technicians need to start all over again if they are interrupted in between. For this purpose, we need a feasible solution which is not only faster than the traditional method, but is also accurate and cost-effective.

Leukaemia can be broadly classified into acute and chronic. This paper focuses on the detection of the Acute Lymphoblastic Leukaemia (ALL) which contributes to about 70% of most of the leukaemia cases every year [3]. Segmentation of the white blood cells from red blood cells in the image of the blood smear is done. The Blood Cell Ratio is then computed to determine presence of increased white blood cells. However, due to the highly complex nature of the cells, the ability of the cells to overlap each other makes this segregation a very tedious task [4].

It is observed that application of thresholding techniques to segregate the white and red blood cells leads to cells with broken boundaries. This can result in a wrong count of the blood cells. This paper proposes determining the convex hull of the cells which gives us an improved result in the context of cell count. The paper is organised as follows: Section II outlines our proposed methodology. The experiments are presented in Section III. Results are discussed in Section IV while Section V concludes the paper.

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II.PROPOSED METHODOLOGY

Our main objective is to develop a robust and cost effective system which can calculate the blood cell count ratio. A patient with suspected leukaemia is likely to have a high count of abnormal leucocytes, which will increase the abnormal to normal blood count ratio. Our proposed methodology, as shown in Figure 1, concentrates on this aspect and is discussed below.

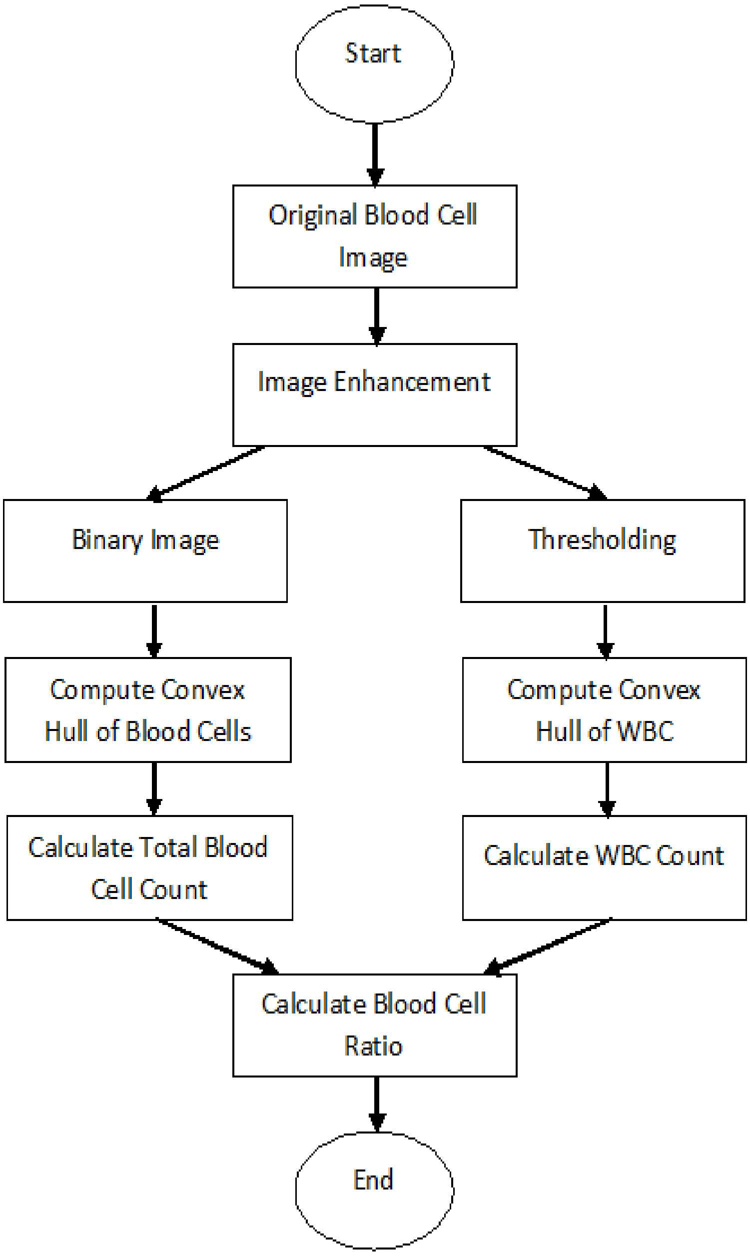

Fig. 1 Proposed methodology

Image Enhancement: Image enhancement of the blood smear image is done by applying Gaussian filter to remove noise and to increase the Signal-to Noise Ratio (SNR).

Thresholding: Thresholding of the filtered image has been in two parts, once for extracting all the cells to give the total blood cell count and the second time to find the stained WBC. The first thresholding is achieved by converting the RGB image into a binary image. Analysis of this image will give us the total blood count.

The second thresholding differentiates between the RBC and the WBC, giving only the WBC as the output. This is done on the basis of the green intensity value of the RGB pixels in the filtered RGB image. Pixels having value less

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than the threshold are assigned binary value 1 while those above the threshold are assigned 0. A binary image is obtained which contains only the white blood cells.

Convex Hull: Convex Hull of a set of points **X** is the smallest convex region containing all the points of **X**. Computation of the convex hull helps us determine the number of connected components. The reason for finding the convex hull is that after threshloding, the cells do not come out to be as one complete entity. This gives us the wrong number of blood cells. Determining the convex hull helps overcome this problem, thereby reducing the chances of error in calculating the blood cell ratio.

Application of this technique in the binary image, containing all cells, gives us the total number of cells. Similarly, number of connected components can be determined in the thresholded image to compute number of white blood cells. Difference of total cell count and white blood cell count gives us number of red blood cells. This helps in the calculation of the blood cell ratio.

Computation of Blood Cell Ratio: In our paper, we have computed the Blood Cell Ratio (BCR) as the ratio of the number of white blood cells to the number of red blood cells. If a person has leukaemia, the number of red blood cells will decrease and number of white blood cells will increase.

$$BCR = \frac{WBC}{RBC} \qquad (2.1)$$

The value of BCR for a normal person is in the range 0~0.1 [5]. A value higher than 0.1 indicates suspected leukaemia in a patient leading to further medical investigations.

III.EXPERIMENTS

Our experiments have been conducted on images of blood smears available freely on the internet. The images are subjected to pre-processing by application of Gaussian filter for noise removal, as shown in Figure 2. The filtered RGB image is first converted into binary image (refer Figures 3 and 4). Convex hull of the cells is determined, as shown in Figure 5. Computation of the number of connected components in this image gives us the total cell count.

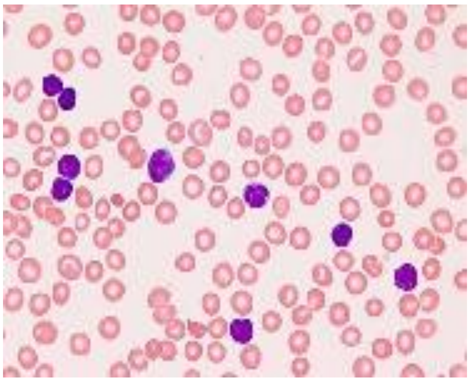

Fig. 2 Blood smear image after applying Gaussian filter

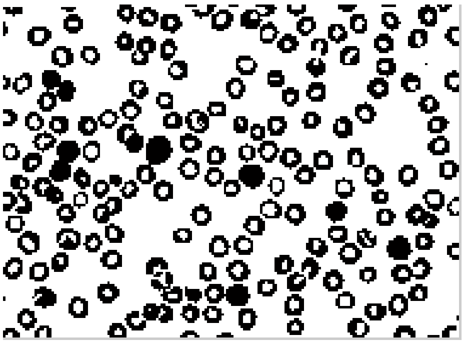

Fig. 3 Binary image

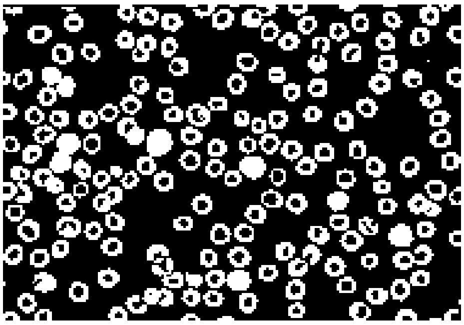

Fig.4 Inverted binary image

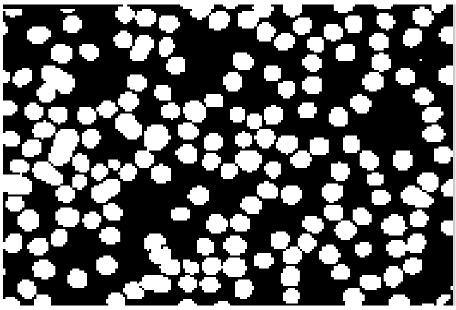

Fig. 5 Convex hull of blood cells

In the next step, the filtered RGB image is thresholded to segregate the red and white blood cells as can be seen in Figure 6. Again convex hull is computed to determine the number of cells (refer Figure 7). This gives us the number of white blood cells in the image. The Blood Cell Ratio is computed to confirm the presence or absence of leukaemia.

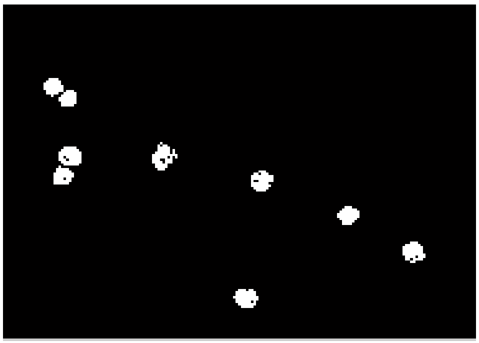

Fig. 6 Extraction of WBC

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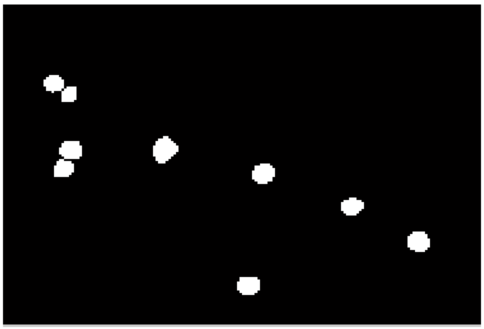

Fig. 7 Convex hull of WBC

IV. RESULTS AND DISCUSSION

Our experiments show that applying convex hull technique to compute number of cells in a given image helps in reduction of error when thresholding does not yield complete images of the cell. Broken boundaries can lead to increased blood cell count leading to false results.

Figure 8 shows us that in the first image, the Blood Cell Ratio comes out to be 0.05 which is for a normal case, whereas in the case of the second image, it comes out to be greater than 0.2, indicating that the patient has leukaemia. The third image here shows us the case of Acute Myeloid Leukaemia (AML) in which the ratio comes out to be higher than what we get in Acute Lymphoblastic Leukaemia (ALL).

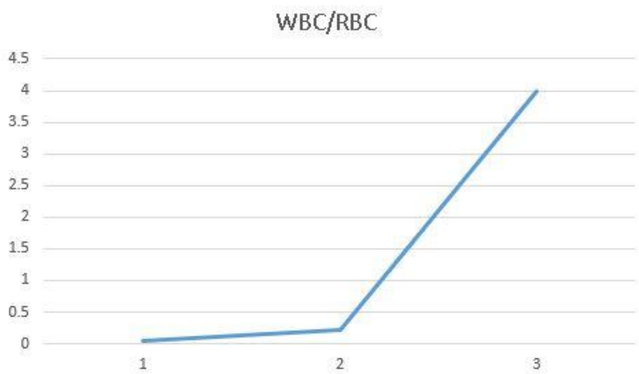

Fig. 8 Graph of WBC/RBC

V. CONCLUSION

As the leukaemia cases are constantly increasing worldwide, the need for finding a robust method for finding the Blood Cell Ratio is gaining importance. In this paper, we have proposed a method using image processing techniques. The Blood Cell Ratio is calculated by applying convex hull to determine number of connected components. The method has shown promising results and has great future scope. Since the paper is written on the basis of ongoing study, the method can be further enhanced and modified.

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