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Identification of Thalassemia disorder using Active Contour

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Abstract

Thalassemia was known as the red blood cell (RBC) morphology disorder. This disease mostly affects the shape of the red blood cells. Thalassemia becomes the major public health problem when one of the people becomes the carrier of the disease. It can occur within a months after birth or even before birth and results in inappropriate growth and development of babies. Sometimes the affected babies will die shortly after birth. In order to screen thalassemia, there are a few tests need to be done. Firstly by performed Complete Blood Count (CBC) and secondly continued with hemoglobin electrophoresis test. This CBC test will identify the morphology of RBC. Hence, this paper will discuss the methods on identifying the morphology of thalassemia blood cells by using active contour technique. From the result of 16 normal and abnormal blood cell images, the active countour methods able to identifyThalassemia blood cells with accuracy of 90% from the abnormal cell images.

Keywords: *Red Blood Cell, Thalassemia, image processing, active contour*

1. Introduction

Red blood cell (RBC) is scientifically known as erythrocytes are the most numerous cells in blood film [1]. Its duty is to carry oxygen all over the body tissue and collects unwanted material from them [2]. Under the stained microscopic images, red blood cells have a circular outline and in pinkish-brown colour. The presentation of hemoglobin affects the colour shade of RBC. In lower hemoglobin value, the colour of RBC is paler under the stained microscopic image. While the changes in shape come from many reasons such as genetic and food intake. Because of the duty on collecting unwanted material, the RBC can create various types of disorder. The common case is including Thalassemia disease.

The Thalassemia disease normally recognized as RBC morphology disorder which forms abnormality in hemoglobin. It affects the shape of the red blood cell. Thalassemia can be categorized into two types which are Beta Thalassemia and Alpha Thalassemia. The different between two of them is based on the alteration in α or β hemoglobin chains [3]. Thalassemia disease can spread world wide if the person has Thalassemia genes become the carrier of the disease. It can occur within months after birth or even before birth. The inappropriate growth and development will occur to the affected babies and children. Because of this blood cell oxygen carrying disorder, sometimes, the babies will not survive to be born or shortly die after birth. Thalassemia early screening is needed to avoid these maternal complications issue during pregnancy.

To diagnose the Thalassemia disease, the expert such as doctors or hematologist will perform a few tests. First step is to run the Complete Blood Count (CBC) test. The CBC tests will measures several components and features in the blood such as RBC and platelet numbers, type and numbers of white blood cells present. Normally, the doctors conclude the CBC test result as Possibilty of Thalassemia blood cell sample. Next step is to run the hemoglobin electrophoresis tests to identify the types and quantity of individual hemoglobin before doctors can confirm it is Thalassemia disease. The morphology of RBC is identified during CBC test. The abnormalities such have target cell, pencil cell or elliptocyte cell types can

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concluded as characteristic of Thalassemia disease [4]. Figure 1 shows the possibility of Thalassemia blood cell image with the present of target cell and pencil cell.

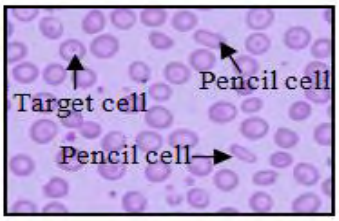


Figure 1. Possibilty of Thalassemia blood cell

Recently, in the others study of Thalassemia disease, the changes of blood cell morphology between normal and Thalssemia disease is detected by using atomic force microscopy [3]. As the result, the morphology of Thalassemia blood cells was smaller and forms a typical crenated compared to normal blood cell. The others study, researcher consider a naïve Bayes classifier and a multilayer perceptron in thalassemia screening. By using the CBC and hemoglobin typing dataset, this naïve Bayes classifier and multilayer perceptron can classify signifantly higher than by using only hemoglobin typing attributes as classifier inputs [5]. In a different study [6], the researcher focused on recognition and determination of thalassemia gene. To determine the thalassemia gene which related to β-globin gene, the usage of an electrochemical biosensor from real samples amplified by polymerase chain reaction (PCR) is applied.

In order to diagnose the diseases based on blood cell morphology, normally the image processing technique is applied. By applying a fews image processing technique, it can bring new initiative in clinical decision. This technique is a software based improvement compared to other methods which using highly cost hardware to perform blood cell identification [7]. There are five basic processes in this automated image processing technique namely image acquisition, image processing, image segmentation, image post-processing and image analysis [8].

In this study, we investigate the first step in diagnosing the Thalassemia disease. To run the automated method, the blood smear sample is converted into blood cell image. Then, the blood cell images undergo a few images processing technique. In image processing tools, the image segmentation process becomes the critical and toughest part to be done. Hence, this study proposed the ways of image segmentation and image analysis on morphology of Thalassemia blood cell. The method we used is active contour method to extract parameters of Thalassemia blood cell.

2. Research Method

This study considers the data samples of normal and abnormal red blood cells from various persons. The abnormal RBC is category as Thalassemia blood cells. The experiment was conducted using the blood cell images. The results are classified into normal blood cell or possibility of Thalassemia disease.

2.1. Data Sample

The data samples are the samples of normal and Thalassemia blood cells disease. About 6 samples of normal blood cell and 10 samples possibilty of Thalassemia blood cell were analysed in this study.The images of normal cell were used as the control image. Usually, the blood cells samples were stained in blood slide. To complete the experiment, we must come out with the blood cell images. The blood cell smears were captured with Olympus DP21 camera with 1600 x 1200 resolutions that attached to an optical laboratory microscope Olympus BX50 at 40x objective lens.

2.2. Image Processing

By using the proposed frameworkas shown in Figure 2 and supported by MatLab software, data images were process to identify the parameter value of each blood cell to check whether it shows the Thalassemia morphology or normal cell morphology.

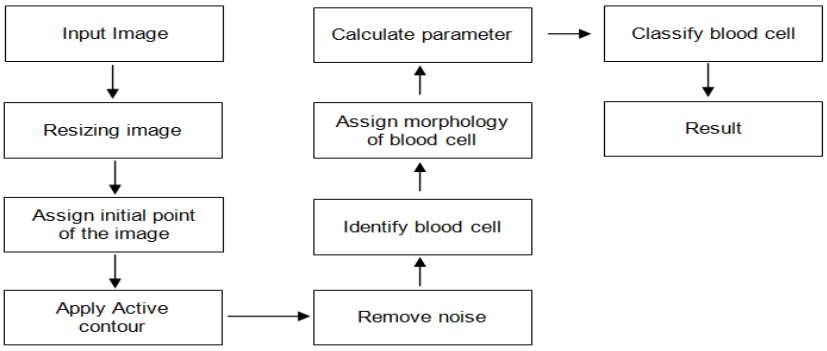


Figure 2. The proposed framework

The steps begin with read the input image from the data sample. Normally, the Red, Green and Blue (RGB) color index comes as the original input image of the dataset. The variable is then created to detect the boundary of this input image. Then, the step continues by creating the variable to calculate the parameter of detected boundary. The result will show in term of normal blood cell type or Possibility of Thalassemia blood cell type. Normal blood cell is tested as the control blood cell images.

2.3. Image Analysis

2.3.1. Boundary Detection

Boundary of blood cell identification includes two steps namely resizing the original and segmentation using active contour method. Boundary detection is made by resizing the input image to become bigger than original image. The resizing original image makes those input images to be fit and easy to be conducted with the segmentation process. In this experiment, the segmentation process is done by using the active contour method. It is using the internal and external energy to run the process in order for initial point to detect the boundary as presented in Equation 1.

$$J_1(C) = \alpha \int_0^1 |C'(s)|^2 ds + \beta \int_0^1 |C''(s)| ds - \lambda \int_0^1 |\nabla \mu_0 (C(s))|^2 ds \quad (1)$$

where, α , β and λ are positive parameter. The first two terms control the smoothness of the contour (the internal energy), while the third term attracts the contour toward the object in the image (the external energy) [9].

2.3.2. Feature Extraction

After the boundary detection of each cells is done, the experiment continues with feature extraction. In order to classify the type of blood cell images, the parameter of each blood cell need to be extracted. The diameter is a cord that runs through the center point of the circle. Figure 3 shows the example of the diameter cord.

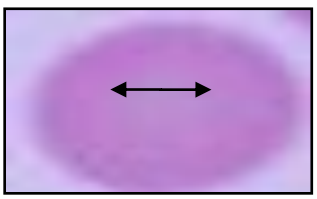


Figure 3. Example of cell diameter

The value of parameter used in this experiment is roundness and eccentricity as presented in Equation 2 and Equation 3 respectively.

$$M = \frac{4 * pi * area}{perimeter^2} \quad (2)$$

M is used to measure roundness of an object. The roundness,*M* value of a circle object is between 0.8 and 1 [10, 11].

$$E = \frac{\sqrt{(major\ axis^2 - minor\ axis^2)}}{major\ axis} \quad (3)$$

E is used to measure eccentricity. It is the ratio of the distance between the foci of the ellipse and its major axis length. The eccentricity value is between 0 and 1 [11]. The value of E = 0 means that the shape is circle while the value of E = 1 resemble a line segment [2].

2.4. Image Classification

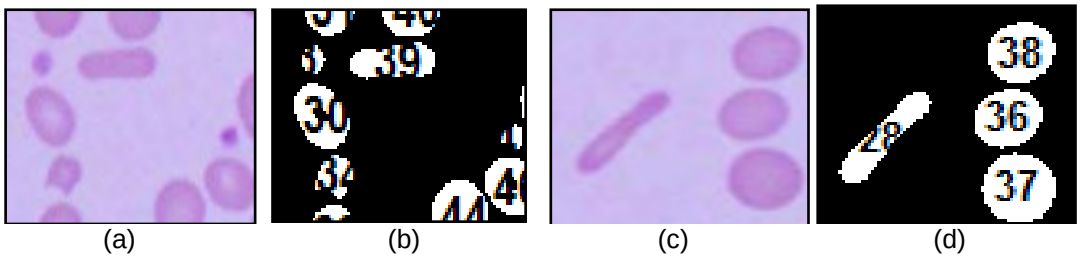
The classification of the blood cells images is running using the extracted parameter. The parameter extracted is roundness and eccentricity. The shape of roundness $M \geq 0.8$ refers to circle. So, the value of $M \leq 0.7$ will refer to ellipse or non-circle shape. In this experiment, because of the shape of the pencil cell is in ellipse shape, we get the roundness value of $M \leq 0.6$ and refer to the Possibilty of Thalassemia blood cell. For the eccentricity value, the ellipse shape shows the value of $E \approx 1$.

3. Results and Analysis

In this section, the classification result of blood cell images is obtained. The experiment is tested by using 16 blood cell images. The proposed method shows slightly good classification result on these blood cell images. Table 1 shows the result of roundness and eccentricity value absed on cells images shown in Figure 4. The cell number refers to each blood cell in image.

Table 1. Result of parameter in for Figure 4

Cell Number	Roundness	Eccentricity
28	0.5	0.976
39	0.6	0.947



(a) (b) (c) (d)

Figure 4. (a) and (c) refer original image, (b) and (d) is segmented cell with cell number

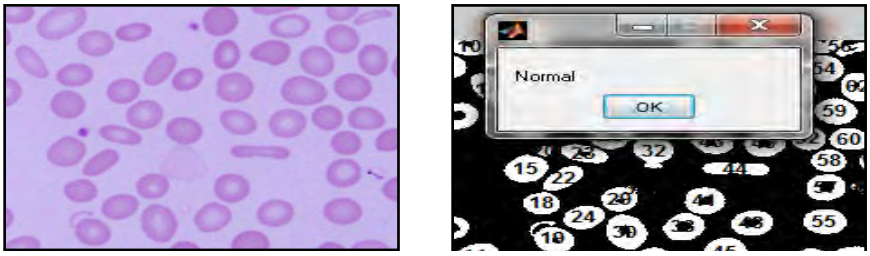
Based on the images analysis is shown in Figure 4, value of roundness and eccentricity for cell number 28 and 39 is 0.5 and 0.976, 0.6 and 0.947 respectively. This value is referring to characteristic of Possibiltyof Thalassemia blood cell. Figure 4 (a) and (c) is refer to original image and Figure 4 (b) and (d) is segmented cell with cell number.

Table 2 shows the results of tested blood cell images. The results shown in form of possibilty of Thalassemia and normal blood cell. This result is acquired after the images went through active contour method. Only Image 11 shows the false detection during this experiment.

Table 2. Result of proposed method

Image	Result
Image 1	Possibility of Thalassemia
Image 2	Normal
Image 3	Normal
Image 4	Possibility of Thalassemia
Image 5	Normal
Image 6	Normal
Image 7	Possibility of Thalassemia
Image 8	Normal
Image 9	Possibility of Thalassemia
Image 10	Possibility of Thalassemia
Image 11	False Detection
Image 12	Possibility of Thalassemia
Image 13	Possibility of Thalassemia
Image 14	Normal
Image 15	Possibility of Thalassemia
Image 16	Possibility of Thalassemia

Figure 5 (a) shows the original image of Image 11and Figure 5 (b) is segmented result for Image 11. The result should be possibility of Thalassemia blood cell, but the result shows the normal blood cell. It is the false detection condition.



(a) (b)

Figure 5. Image 11(a) Original image (b) segmented result

Table 3 shows the accuracy of the proposed method. From the sample, about 6 image of normal cell is detected correctly. For Thalassemia, 9 out of 10 images are correctly identified that produce 90% accuracy.

Table 3. Accuracy of the system in detecting Thalassemia

Results	Accuracy
Normal blood cell	6 out of 6 image $\frac{6}{6}\ x\ 100\ \% = 100\%$
Possibilty of Thalassemia blood cell	9 out of 10 image $\frac{9}{10}\ x\ 100\ \% = 90\%$

4. Conclusion

In summary, we investigated the first step of diagnosing Thalassemia disease which is Complete Blood Count (CBC) test. We use the active contour method supported with roundness and eccentricity parameter in order to classify the normal and possibility of Thalassemia blood

cell images. From the result given, we can concluded that about 15 out of 16 images were correctly been classify as their blood cell type.

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