SICKLE CELL IDENTIFICATION USING IMAGE PROCESSING AND RED BLOOD CELL MORPHOLOGICAL CHARACTERISTICS

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DEDICATION

This thesis is dedicated to my parents, who taught me that the best knowledge is that which benefits the humanity.

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Alhamdulillah. Indeed, all praise is due to Allah. We praise Him and seek His help and forgiveness. We seek protection with Allah from our soul's evils and our wrong conducts. He whom Allah guide, no one can misguide; and he whom He misguides, no one can guide.

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ABSTRACT

Blood is the most vital liquid that helps sustain the healthiness and life of the human body. Biologically, normal red blood cells have circular shapes and play a key role in transporting oxygen and nutrient to tissues. Red blood cells are bendable, which allows them to pass through the veins and arteries smoothly. Sadly, there are exceptional individuals with abnormal blood cells call sickle cell disease. The physical shape of the abnormal blood cells is in sickle/crescent form. Sickle cell disease is hereditary, and a person becomes affected if at least one of the parents has the abnormal haemoglobin S gene. The danger of sickle cells is that they inflict many severe health conditions such as pain, tiredness, jaundice, kidney problem, and other critical illnesses. For many years, managing and diagnosing sickle patients is performed by collecting blood samples to manually observe the irregular shapes of the red blood cells using a microscope. This process is time-consuming and results in errors for large samples of blood. In this thesis, a compelling image processing method is proposed to optimize the detection of abnormality in human blood cells with the deep learning technique. Ten images of red blood cells were randomly collected from the online source using the Google search engine. Each image was analyzed using MATLAB codes for image processing using the blood cell area, eccentricity, diameter, extension, and form factor as input parameters. The study results show that the proposed technique has 71 – 100 percent accuracy, far higher than what is obtainable in the manual method. This technique can serve and enhance the current manual method of sickle cell segmentation because it is faster and more accurate.

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ABSTRAK

Darah adalah cecair yang paling penting yang membantu mengekalkan kesihatan dan kehidupan tubuh manusia. Secara biologi, sel darah merah normal mempunyai bentuk bulat dan memainkan peranan penting dalam mengangkut oksigen dan nutrien ke tisu. Sel darah merah dibengkokkan, di mana membolehkannya melancarkan urat dan arteri dengan lancar. Malangnya, ada individu yang luar biasa dengan sel darah yang tidak normal yang disebut penyakit sel sabit. Bentuk fizikal sel darah yang tidak normal adalah dalam bentuk sabit / sabit. Penyakit sel sabit turun temurun dan seseorang akan terjejas sekiranya sekurang-kurangnya salah seorang ibu bapa mempunyai gen hemoglobin S yang tidak normal. Bahaya sel sabit adalah bahawa mereka menimbulkan banyak keadaan kesihatan yang teruk seperti sakit, keletihan, penyakit kuning, masalah ginjal, dan penyakit kritikal lain. Selama bertahun-tahun, pengurusan dan diagnosis pesakit sabit dilakukan dengan mengumpulkan sampel darah untuk memerhatikan secara manual bentuk sel darah merah yang tidak teratur menggunakan mikroskop. Proses ini memakan masa dan mengakibatkan kesilapan ketika sampel darah yang besar akan diuji. Dalam kajian ini, kaedah pemprosesan gambar yang berkesan dicadangkan untuk mengoptimumkan pengesanan kelainan pada sel darah manusia dengan bantuan teknik pembelajaran mendalam. Sepuluh gambar sel darah merah dikumpulkan secara rawak dari sumber dalam talian menggunakan mesin carian Google. Setiap gambar dianalisis menggunakan kod MATLAB untuk memproses gambar menggunakan luas sel darah, eksentrik, diameter, pemanjangan, dan faktor bentuk sebagai parameter input. Hasil kajian menunjukkan bahawa teknik yang dicadangkan memiliki ketepatan 71 - 100 peratus, yang jauh lebih tinggi daripada yang diperoleh dalam kaedah manual. Teknik ini dapat berfungsi dan meningkatkan kaedah manual segmentasi sel sabit kerana lebih cepat dan tepat.

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LIST OF ABBREVIATIONS

HbA	-	Adult Haemoglobin
HbS	-	Sickle Haemoglobin
RBC	-	Red Blood Cell
SCA	-	Sickle Cell Anaemia
SCD	-	Sickle Cell Disease

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Sickle cell disease (SCD) is an inheritable abnormality in the human red blood cell (RBC). In a healthy person, the RBCs are circular and perform the function of transporting oxygen and nutrients to all parts of the body. On the contrary, persons with SCD have their blood cells in a sickle-shaped/crescent appearance. This abnormality in the RBC shape is known as sickle cell anaemia (SCA) [1, 2]. In individuals with SCA, the red blood have unbendable shapes. They have a rigid structure that clogs the veins and arteries, thereby restricting the smooth flow of blood in the body. For this reason, people with SCA suffer from different health abnormalities and complications such as slow growth, fatigue, fast heart rate, jaundice, and other related sicknesses [3, 4].

In the field of biochemistry, "haemoglobin is the conjugated protein, consisting of haem and the protein globin, that gives red blood cells their characteristic colour" [5]. The haemoglobin undergoes an irreversible reaction with oxygen to form oxygenated blood transported to all body tissues. Unlike other non-communicable diseases, the SCD is heritable. When a person is affected with SCD, the victim has inherited an abnormal haemoglobin gene (haemoglobin S gene) from a parent. Patients with SCD naturally inherit at least one-abnormal haemoglobin from any of the parents [6]. The categories of SCDs are:

a) Haemoglobin Sβ0 thalassemia
b) Haemoglobin Sβ+ thalassemia
c) Haemoglobin SC
d) Haemoglobin SD

e) Haemoglobin SE

f) Haemoglobin SS (also known as the SCA)

The example of SCD condition and how it is inherited from parents is shown in Figure 1.1.

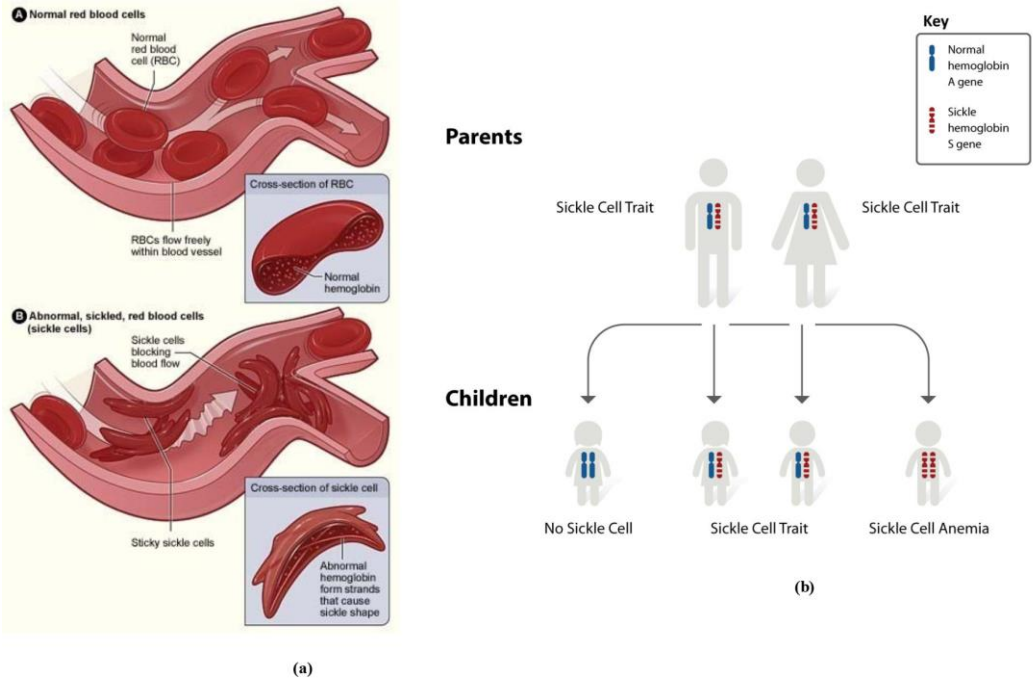

Figure 1.1 An example of (a) SCD condition and (b) hereditary chain from parents to a child

Over the past decades, the classification of sickle cells using the manual technique to observe and classify abnormal RBCs using microscopes. The manual method of RBC segmentation has several drawbacks. It is time-consuming, tedious, and accuracy is low when the blood image samples are many [7]. In the past years, image processing using deep learning has gained numerous applications in medicine and healthcare services. For instance, by employing deep learning algorithms, many RBC images can be segmented promptly. Besides, the level of accuracy and effectiveness is improved [8-12].

In this study, the metric and implemented algorithm is employed to identify normal and abnormal RBCs. The classification of RBCs is performed based on image

properties such as colour, shape, and texture. Through image segmentation, it is possible to categorize RBCs based on the area of the cell, eccentricity, and form factor.

1.2 Problem Statement

The manual identification of normal and abnormal RBCs under the microscope is cumbersome and results in undesirable RBC classification errors. Many studies have proposed deep learning for biomedical image processing of RBCs. This research aims to identify the characteristics of SCA by using red blood cell morphological characteristics using component analysis and comparison to segregate the sickle cells based on their characteristics such as area, eccentricity, diameter, extension, and form factor. The method is simple and straightforward without the need for medical experience to identify abnormal RBCs from many blood samples.

1.3 Objectives of the Study

The objectives of the study are:

a) To identify and count numbers of sickle cells in the input image.
b) To identify the best medical image algorithm for recognizing SCA.
c) To detect the presence of abnormalities in blood smear image by a deep learning algorithm

1.4 Research Scope

To accomplish the stated objectives, previous studies are reviewed to determine the most suitable image processing algorithm. MATLAB 2019a is employed for coding and designing an algorithm that would optimize the images of the selected RBCs to detect abnormalities and observe changes in the cells' physical features. All images utilized are from online secondary sources.

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