ALGORITHMS FOR LEUKAEMIA IMAGE EDGE DETECTION TECHNIQUE

by

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LIST OF ABBREVIATIONS

ACO	Ant Colony Optimization
WBCs	White Blood Cells
RBCs	Red Blood Cells
FIS	Fuzzy Inference System
DT-CWT	Dual-Tree Complex Wavelet Transform
RGB	Red Green Blue
HSV	Hue-Saturation Value

Algoritma Untuk Teknik Pengesanan Pinggir Imej Leukemia

ABSTRAK

Pengesanan pinggir merupakan operasi pra-pemprosesan yang penting dalam pemprosesan imej dan pengecaman corak. Ia melibatkan proses pengenalpastian dan pengesanan bagi ketidakselanjaran secara tiba-tiba untuk mengeluarkan maklumat yang bermakna dari sesuatu imej. Pengesanan pinggir memudahkan analisis imej dengan mengurangkan jumlah data yang akan diproses dan menapis maklumat yang tidak mencukupi secara drastik dan pada masa yang sama memelihara struktur maklumat yang berguna tentang sempadan susuatu objek dalam imej. Ketidakselanjaran menandakan perubahan mendadak dalam keamatan piksel yang menggambarkan sempadan objek di sesebuah lokasi. Tujuan kajian ini adalah untuk mengesan pinggiran leukemia dalam imej sel darah putih. Bagi mencapai matlamat ini, dua prosedur tersendiri dilaksanakan iaitu Algoritma Pengoptimuman Koloni Semut dan Pengesanan Tepi Kecerunan (Sobel, Prewitt dan Robert). Proses yang terlibat kemuadianna adalah penapisan imej, penduaan, Penapisan Kekusutan Kernel dan Transformasi imej. Sementara itu, ACO melibatkan penapisan, peningkatan, pengesanan dan penyetempatan bagi pinggirani. Akhir sekali, pelaksanaan kaedah pengesanan pinggiran ACO, Sobel, Prewitt dan Robert dibandingkan untuk menentukan kaedah terbaik bagi pengesanan pinggiran yang menghasilkan pinggiran sebenar yang optimum bagi imej leukemia dalam sel darah putih. Penemuan kajian menunjukkan keputusan tersendiri di mana kelebihan kaedah pengesanan Prewitt telah menghasilkan prestasi optimum untuk mengesan pinggiran sel-sel leukemia dengan nilai sebanyak (5982) piksel aktif. Sementara itu, ACO, Sobel dan Robert masing-masing menghasilkan keputusan prestasi (2970),(5318) dan (3810). Keseluruhan penemuan menunjukkan bahawa kelebihan kaedah pengesanan kecerunan adalah lebih berbanding dengan kaedah Pengoptimuman Koloni Semut.

Algorithms For Leukemia Image Edge Detection Technique

ABSTRACT

Edge detection is an essential pre-processing operation in image processing and pattern recognition. It involves identifying and tracing the sharp sudden discontinuities to extract meaningful information from an image. Edge detection simplify the analysis of an image by drastically reducing the amount of data to be processed and filtering out inadequate information, while at the same time preserving useful structural information about object boundaries in an image. The discontinuities signify the sudden changes in pixel intensity which describes boundaries of objects in a scene. The purpose of the present study is to detect the leukaemia edges in the white blood cell image. Toward this end, two distinctive procedures are implemented which are Ant Colony Optimization Algorithm and the gradient edge detectors (Sobel, Prewitt and Robert). The latter involves image filtering, binarization, kernel convolution filtering and image transformation. Meanwhile, ACO involves filtering, enhancement, detection and localization of the edges. Finally, the performance of the edge detection methods ACO, Sobel, Prewitt and Robert is compared in order to determine the best edge detection method which yielded optimal true edges of leukaemia in the white blood cell image. The results revealed distinctive results whereby the Prewitt edge detection method produced optimal performance for detecting edges of leukaemia cells with a value of (5982) active pixels. Meanwhile, the ACO, Sobel and Robert yielded active pixels of (2970), (5318) and (3810) respectively. Overall findings indicated that the gradient edge detection methods are superior to the Ant Colony Optimization method.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Edge detection is an essential operation in numerous fields such as medical imaging, shape recognition, defect detection on mechanical parts and various industrial and machine vision applications (Liu & Fang, 2015). Edge detection is used to identify and locate the sudden significant changes and discontinuities in digital images such as photometrical images, physical geometrical characteristics, leukaemia blood cells and etc. (Muthukrishnan & Radha, 2011; Pratt, 2001; Trujillo & Olague, 2006).

Generally, edges are significant local changes or sudden discontinuities which normally occur on the boundaries of two different regions in the digital images and often carries useful physical information (Fan, Song, & Jutamulia, 2007). The edges in an image indicate higher frequency information of an object and hence they play important role in image processing and pattern recognition (Sherin & Mredhula, 2017). They characterize boundaries and thus have a wide range of useful applications including segmentation, pattern recognition and identification of objects in scenes. Indeed, edges signifies significant visual information of the object in an image because they relate to the major geometrical, physical, and photometrical variations in scene object in the digital images (Verma, Sharma, & Kumar, 2012).

An edge can be defined as a group of connected pixels lying between boundaries of two regions in an image. In binary images, edges are the black pixels with one nearest white neighbour. Apart from this, image edge detection is the process of detecting and extracting edges from digital images to retrieve important details of image analysis. Therefore, detecting edges plays a crucial role in many applications in the field of image processing and computer vision. Indeed, edge detection is very important operation in image analysis applications such as image registration, scene's object identification and image segmentation (Lu & Chen, 2008).

Due to the importance of image edge detection for analysing the sudden changes and discontinuities in an image, various researchers have implemented edge detection methods in medical image processing such as (Abood, 2013; Chalana & Kim, 1997; Maulik, 2009; Nee, Mashor, & Hassan, 2012; Reta et al., 2015; Salem, Sobhy, & El Dosoky, 2016; Yeganeh, Mir, Mirnia, Branch, & Branch, 2015).

Over the years, various edge detection algorithms have been proposed which are categorized into first order edge detectors (gradient edge detectors), second order edge detectors and artificial intelligence and optimization algorithms. The latter includes fuzzy neural networks, genetic algorithm, ant colony optimization algorithm and etc. The gradient edge detection methods include canny edge detector and the classical edge detectors (Robert, Prewitt and Sobel operators). The detection of edges in the gradient method is usually carried out through the close observation of minimum and maximum first derivatives of an image (Fan et al., 2007; Sun, Hou, Tan, & Li, 2014)(a), Sun, Hou, Tan, & Li, 2014)(b).

The principle of edge detection process involves four primary interrelated steps which are filtering, enhancement, detection and localization (Ramadevi, Sridevi, Poornima, & Kalyani, 2010). Filtering is essential pre-processing operation that is used to suppress or reduce noises in an image. Noise removal is intended to remove noises while maintaining the true edges of an image which improve the performance of edge detector with respect to noise (Poornima, Ramadevi, & Sridevi, 2011). Digital images are often corrupted by various noises which refer to the variations in the intensity of an image. Undoubtedly, the amount of noise in an image reduce the precision of edge detection operation.

Despite the importance of filtering process, selecting the appropriate filters is crucial criterion in image processing field. Indeed, filtering may affect the strength and degrade the contents of the edges in an image. Thus, the major concern in edge detection filed lies in the scale of the filters. For instance, the large-scaled filters provide robust noise removal but they may filter fine details of an image. Meanwhile, the small-scaled filters are not robust as they are susceptible to edge signals in an image. Hence, depending on the type of filter specific edge features are filtered in the images.

In fact, in order to facilitate accurate edge detection, it is essential to determine changes in intensity in the neighbourhood of a point. The edge detection is carried out with the strong edge contents which usually contain the information needed to describe the content of an image. Distinguishing strong edges among the weak ones is essential criterion which determines the efficiency of the edge detection methods. For instance,

thresholding can be employed for determining the true edge points in an image (Rajeswari & Rajesh, 2011).

Besides filtering and enhancement processes, binarization is a crucial operation in edge detection process. It is the process used to convert the grey scale images into a black and white images which can be archived by the local of global thresholding (Verma et al., 2012). The importance of binarization arise from its crucial role to decease the computational process of grey level image information in order to facilitate detection of edges in an image. Nonetheless, the localization process determines the true locations of an edge in digital images which often is required for some applications.

In fact, detecting the leukaemia in blood cells is still a major challenge and active research in medical image processing. It has become imperative to develop algorithms that can detect and trace the immature cancerous cells in blood. In this regard, edge detection operation serves to reduce the analysis of medical image (white blood cells) by drastically simplifying the amount of data to be processed, while at the same time maintaining meaningful structural information about object (leukaemia) boundaries.

In the present study, various edge detection techniques including; Ant Colony Optimization algorithm, Sobel, Prewitt, Roberts are employed to extract the edges of leukaemia cancerous cells from blood image. Toward this end, the acquired blood cells are first pre-processed to suppress noises, to sharpen and to smoothen the white blood

cells image. In this case, noise removal is carried out using linear (mean) filter. Mean filter is capable of removing noises while preserving important details of an image

The next stage involves sorting the leukaemia cells from the normal blood cells using the kernel single and multi-phases background elimination process. Furthermore, the binarization process is carried out to convert the leukaemia pixels into a binary image. The binary images are digital images which have only two possible values for each pixel which are black and white colours. The colour used for the leukaemia in the image is the foreground colour while the rest of the image is the background colour. In order to capture the true edge colour image of the Leukaemia cells, the extracted leukaemia cell pixels are transformed to the original image using the transformation process.

The next step involves the use of the gradient edge detection methods; Sobel, Prewitt and Robert to recognize the pattern of the leukaemia cells. Apart from this, Ant Colony Optimization (ACO) edge detection method is utilized to detect, recognize and extract the patterns of the leukaemia cells from the white blood cell image. The final stage of this study concerns about performance comparison of the gradient edge detectors and the ACO edge detection methods to identify the optimal edge detection method.

1.2 Research Problem Statement

Despite the existence of various edge detection algorithms, edge detection remains one of the most challenging field in image processing. The major challenge in image edge detection is finding true edges. Edge detection is essential operation in image processing process because it involves filtering, enhancement, detection and localization operations. In fact, finding the optimal boundaries of an image in order to obtain specific information and features such as detecting leukaemia blood cells in the blood is a challenging criterion in medical image processing. Undoubtedly, the implementation of the conventional edge detection methods is not sufficient to extract the patterns of leukaemia cells from blood images.

Indeed, to mark up the true edges of leukaemia cells is phenomenon task in image processing. This is due to the complexity of recognizing the sharp intensity changes of the cancerous leukaemia cells with the blood cells especially at the early stages. In fact, employing the appropriate edge detection filters to extract the relevant information from the images while sustaining the essential attributes of the image is critical task in image processing. This is because distinct edges (boundaries) in medical images may not exist and are extremely difficult to be detected due to the similarity between the blood cells and the presence of noises. Moreover, due to the partial volume effects caused by the imaging device's resolution, the boundaries of an image may be ambiguous and blurred. These obstacles make the segmentations of neighbouring structures in medical images a challenging tasks.

Apart from this, leukaemia is a cancerous disease of white blood cells that causes the infected immature white blood cells to increase uncontrollably. This process leads to the destruction of the immune system and death. More importantly, the current procedure for detecting leukaemia in the blood cells involves taking a sample of the blood and examining it by haematologists. However, this procedure is prone to human judgements and errors, time consuming and tedious and is incapable of detection immature leukaemia cells at early stages. Therefore, in spite of numerous proposed algorithms, comparison and research is needed in this field.

1.3 Research Objectives

The main objectives of this study are:

i. To detect the edges of leukaemia through filtering, sorting process, kernel multiphase convolution, binarization and transformation techniques.

ii. To employ Sobel, Prewitt and Robert edge detection to recognize the pattern of the detected leukaemia cells in the white blood image.

iii. To utilize Ant Colony Optimization (ACO) algorithm to detect, extract and recognize the edge boundaries of the leukaemia cells from the white blood cell image.

iv. To compare the performance of the gradient edge detection methods (Sobel, Prewitt and Robert) with the ACO method to determine the optimal edges of the leukaemia cells.

v. To describe the features of white and red blood cells based the detected edges through the visual comparison.

1.4 Research Scope

The specific scope of this study is to detect, filter and extract the edge features of leukaemia cancerous cells in blood image. The leukaemia cancerous cells are a type of digital RGB images. This study is limited to the coloured blood images of Red Blue Green (RGB) plane. It is not applicable for grey scale images.

1.5 Research Significance

The present study emphasizes the implementation of various edge detection methods to detect and recognize the patterns of leukaemia cancerous cells in blood images. Detection of leukaemia edges in white blood cells is essential to recognize immature cancer cells at early stages so that the treatment can be efficient. The study significances are to, filter, detect and recognize the true edges of leukaemia cells in the blood. In addition, the study demonstrates the implementation of linear (mean) filter to suppress the noises and to smoothen the image. Besides, various edge detection methods including Sobel, Prewitt, Roberts and Ant Colony Optimization methods are

employed to extract the patterns of leukaemia cells. In addition, the present study contributes to the grown literature of detecting leukaemia cells in medical image processing by presenting a literature on the most significant studies related to edge detection and leukaemia.

1.6 Dissertation Organization

This thesis comprises of FIVE chapters, which are illustrated as follows:

Chapter 1 is dedicated to demonstrate the general introductory and importance of edge detection operation in digital image processing, machine vision, image classification and pattern recognitions. Besides introducing the edge detection technique and illustrating its significance in image processing, this chapter presents the problem statement, objectives, and scope of the present study. Finally, it ended up with the thesis organization and a summary of the chapter.

Chapter 2 is devoted to present the significant literature of edge detection, gradient edge detection methods and Ant Colony Optimization (ACO) algorithm. It contains; introduction, background, edge detection, ACO, gradient edge detectors (Sobel, Prewitt and Robert), summary of gradient edge detectors and edge detection of leukaemia. Throughout the sections of this chapter, a review of the most significant studies is conducted. The importance of this chapter comes from the fact that it serves as the initial stage towards understanding and reviews the empirical studies, finding the relevant jabs and methods used in edge detection.

Chapter 3 is designated to illustrates the methods utilized in this study to solve the problem statements and to achieve the objectives of this research. It comprises of introduction, methodology flowchart, image acquisition, pre-processing, gradient edge detection methods (Sobel, Prewitt and Robert) and Ant Colony Optimization (ACO) edge detection.

Chapter 4 is intended to present and discuss the obtained results in this study. This chapter contains introduction, acquired white blood cell image, pre-processing results, binarization results, transformation results, gradient edge detection methods results, Ant Colony Optimization (ACO) algorithm results and performance comparison.

Chapter 5 is the final chapter which is devoted to conclude and remark the overall findings, to address the objectives of the study and to states the limitations and implications of the present study. It includes introduction, limitation and recommendations, future research and conclusion.

1.7 Summary

This chapter presented the general introductory of edge detection and its importance and applications in image processing and medical imaging. Besides that, it also addressed the objectives, problem statements, scope and significance of the present study. It also demonstrated the importance of conducting this study to detect the edges

of leukaemia cancerous cells in the blood. Finally, this chapter ended up with the thesis organization as well as a summary of the chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is dedicated to present the literature review of this study. It serves as the initial stage toward understanding the edge detection operation in image processing. It also assists at identifying the jabs and reviews the relative significant studies on edge detection. It contains introduction, background, edge detection, Ant Colony Optimization (ACO) algorithm, Sobel, Prewitt and Robert edge detection methods and edge detection of leukaemia cells. The present chapter is organized as follow, the background of edge detection, leukaemia cells, history and applications of various edge detection methods are presented in section "Background". The definition and applications of Ant Colony Optimization (ACO) algorithms to solve edge detection problems are illustrated in section "Ant Colony Algorithm". In addition, sections "Gradient Edge Detectors" and "Edge Detection of Leukaemia cells" present the types of gradient edge detectors employed in this research and edge detection methods for segmenting and detecting leukaemia cells respectively.

2.2 Background

Edge detection is a crucial operation in image processing which aims to identify and locate edge points in an image. Digital image is an array of small integer numbers knowing as pixels. The pixels are the basic elements or units of the colours on an image

which signifies the resolution of images. The importance of edge detection comes from its significant role at searching and extracting the true edges to provide useful information for further image analysis (Yeganeh et al., 2015).

Over the past decades, medical image processing has become an essential method to interpret and visualize medical images. As a result, researchers have developed multiple powerful methods for storing, detecting, transmitting, displaying and analysing medical images. However, the most challenging aspect of medical imaging lies in the development of an optimal algorithm that can detect cancerous cells with better accuracy and efficiency (Mahaja, Golait, Meshram, & Jichlkan, 2014).

Apart from this, leukaemia is a cancer disorder which affects the White Blood Cells (WBCs), whereby immature and abnormal WBCs are produced vigorously by the bone marrow into the bloodstreams (Chin Neoh et al., 2015). In the context of medical diagnosis, the existence of the leukaemia is identified when the blood samples are taken and examined by haematologists. Blood is the primary source of information which gives an indication of the sudden changes pertaining to leukaemia cells. These changes are detected based on the appearance or the number of the blood elements which indicate abnormal conditions (Reta et al., 2015). Image edge detection methods detect the leukaemia by producing a line drawing on the image, which highlights the sharp changes or discontinuities of the intensity (boundaries of the leukaemia) in the blood images. To exemplify, the boundaries of an object in an image refers to the sharp discontinuities in the intensity of an image where different objects possess different intensity changes in an image (Poornima et al., 2011).