

LEARNING TOOL OF IMAGE SEGMENTATION TECHNIQUES FOR NEW
LEARNERS

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*Specially dedicated to my family, lecturers, fellow friends and those who have guided
and inspired me throughout my journey of education*

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ABSTRACT

Image segmentation is an essential step for other image processing steps. There are plenty of image processing tools in the market but most of them are not research and education based. There are only few from the remaining ones which are suitable and widely being used by new learner and MATLAB is one of them. Although MATLAB is open source and well established but limited interactive applications focusing on image segmentation targeting for new learners. Discussion and open forum are mostly reviewing advance image processing techniques. However, the fundamental of image segmentation cannot be neglected as it affects all other image processing applications later. Most of the time, new learner spent longer time understanding the tool instead of familiarize with the algorithm and theory behind the image segmentation. The purpose of the project is to develop an interactive learning tool for image segmentation targeting for new learners. In this project, an interactive Graphical User Interface, GUI which is based on MATLAB is being introduced as survey shows that undergraduates from Universiti Teknologi Malaysia, UTM prefer and more frequent to use MATLAB solving image processing related issues. The Learning Tool of Image Segmentation covering most of the fundamental images segmentation techniques; such as point detection, line detection, edge detection, thresholding, region growing, Watershedding and K-Mean clustering. Information displayed on each and every step helps users to understand better the algorithm, theory and Application Programming Interface, API for the method. Guidance and questions at Message Window increase the curiosity of image segmentation and custom segmentation options motivates new learners for trial and error.

ABSTRAK

Segmentasi imej merupakan satu langkah penting untuk pemprosesan imej yang lain. Terdapat banyak aplikasi pemprosesan imej di pasaran tetapi kebanyakannya bukan untuk matlamat penyelidikan dan pendidikan. Aplikasi yang sesuai dan sering digunakan oleh pengguna yang baru adalah sangat sedikit. *MATLAB* adalah salah satu daripada aplikasi-aplikasi yang sesuai. Walaupun *MATLAB* adalah sumber terbuka dan mantap tetapi aplikasi interaktif yang memberi tumpuan kepada segmentasi imej untuk pelajar baru adalah terhad. Kebanyakan perbincangan dan forum terbuka mengkaji teknik pemprosesan imej yang lebih canggih. Walau bagaimanapun, asas segmentasi imej tidak boleh diabaikan kerana ia boleh menjejaskan aplikasi-aplikasi pemprosesan imej yang lain nanti. Kebiasaannya, pelajar baru perlu meluangkan masa yang lama untuk memahami peralatan itu dan bukannya memanfaatkan masa dengan memahami algoritma dan teori di sebalik segmentasi imej. Tujuan projek ini adalah untuk membina satu aplikasi pembelajaran interaktif yang menumpukan perhatian kepada segmentasi imej untuk pelajar baru. Dalam projek ini, *Graphical User Interface, GUI* interaktif yang dibina atas aplikasi *MATLAB* diperkenalkan. Kajian menunjukkan bahawa mahasiswa dari Universiti Teknologi Malaysia, UTM lebih suka dan lebih kerap mengguna *MATLAB* untuk menyelesaikan masalah-masalah berkaitan dengan pemprosesan imej. Aplikasi Pembelajaran Segmentasi Imej meliputi kebanyakan teknik asas segmentasi imej; seperti pengesanan titik, pengesanan garis, pengesanan pinggir, *thresholding*, *region growing*, *Watershedding* dan *K-Mean Clustering*. Maklumat yang dipaparkan semasa pengguna melancarkan sesuatu langkah segmentasi imej akan membantu mereka untuk memahami algoritma, teori dan *Application Programming Interface, API MATLAB* dengan lebih baik. Selain itu, maklumat tersebut akan meningkatkan lagi rasa ingin tahu mereka and secara tidak langsung membimbing mereka untuk mencuba teori segmentasi sendiri.

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LIST OF ABBREVIATIONS

GUI	-	Graphical User Interface
API	-	Application Programming Interface
2D	-	2 Dimensional
LoG	-	Laplacian of a Gaussian
ITK	-	Insight Segmentation and Registration Toolkit
ILASTIK	-	Interactive Learning and Segmentation Toolkit
SPM	-	Statistical Parametric Mapping
UTM	-	Universiti Teknologi Malaysia
RGB	-	Red Green Blue

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Segmentation is the process of dividing images into constituent regions or objects [1]. As manual image segmentation is time consuming and the size and numbers of medical images have increased, therefore automatic methods are widely being discussed and applied. Until today, image segmentation is still a top and challenging topic. Segmentation accuracy determines the eventual success or failure of computerized analysis procedures. The level of detail to which the subdivision is carried depends on the problem being solved because there is no point to continue subdivision the image if the detail required to identify those elements has obtained [2, 3].

In general, there are two groups of image segmentation techniques; which are discontinuity and similarity. The top three image segmentation techniques which are widely being applied according to a research paper on medical image segmentation methods and software [1] are thresholding, region growing and edge tracing. Segmentation using threshold value is a simple yet effective method which may apply in gray scale or color images to distinguish regions with contrasting intensity levels. Segmentation on biomedical images by using region growing method separates particles that touch each other. It shrinks objects to seed points, and grows to original size with the pixels that touching neighbor object to be white. Where edge detection forms an edge image after which edge pixels with adjacent neighbor

connectivity are followed sequentially and collected into a list to represent an object boundary [1, 3].

Each of the image segmentation methods has own advantages and disadvantages and so most of the time they are not applied individually. Different algorithms or models may apply together on each method in order to cover each other to complete a full image processing application [2]. As image segmentation is an essential topic on image processing techniques, it is always being included for subject digital image processing. New learner will first need to understand the fundamental of image segmentation before moving on to explore other advance topic.

A good image processing learning tool cultivates interest of users and motivates them to explore advance techniques. Although there are uncountable image processing tools in the market but most of them are commercialized and do not meant for research and education purposes. In the following, an image segmentation learning tool is being introduced which meeting the criteria of a good learning tool; which are high performance, high output quality, interactive and user friendly.

1.2 Problem Statement

The analysis of biological high content images often requires segmentation as a first step. The important of image segmentation promoted it to become the compulsory subject in digital image processing subject. A good image segmentation learning tool motivates new learners to achieve higher with shorter time. Although there are plenty of image segmentation tools in the market, however most of them are not developed for research and education purposes. As a result, new learners spending much more time dealing with the tool rather than beneficial the time with deepen the knowledge in image segmentation algorithm and theory. Besides that, most of the image processing tool do not have all fundamental image segmentation techniques but only covers some which are needed for their applications. This situation is worse for new learners who do not familiar with programming languages.

As a result, new learners like undergraduates always depend on the experience tutor to complete their assignments.

1.3 Objectives

The objective of this project is to develop a learning tool focusing on image segmentation, which is user friendly, high performance, effective and easy to understand. The image segmentation learning tool covers most of the fundamental techniques of image segmentation. The output image is effective with high performance. Info message and guidance benefit new learners to understand image algorithm and theory of segmentation better. An interactive Graphical User Interface, GUI is developed with clear instruction and functions so that it is user friendly.

1.4 Scope of Work

In order for the project to achieve its objectives within the duration of the given timeline, it would be best that we list down the breadth and depth of the scope of work so that effort and focus will not go astray.

1. This learning tool is focusing on fundamental image segmentation techniques and does not cover advanced techniques or other image processing applications due to the limited resources.
2. This learning tool is targeting the undergraduates who are studying biomedical and digital image processing subjects.
3. This learning tool is developed based on MATLAB as MATLAB is commonly used by most of the undergraduates in Malaysia. This tool should be able to run on Windows 7 and it should be able to run for all 2D biomedical images that are being used as teaching materials in Universiti Teknologi Malaysia, UTM.

1.5 Significance of Study

This study provides a user friendly and interactive interface based on MATLAB for new learners to apply fundamental image segmentation techniques on given assignments so that they can understand and familiarize with algorithm and theory behind image segmentation.

1.6 Thesis Overview

This thesis comprises of five chapters with each discussing in detail on the aspects related to this project. Chapter 1 consists of the introduction, objectives, scope of work as well as significance of the project. Furthermore it also provides a brief introduction on the project environment and specifies the object of interest. Chapter 2 provides literature review on few published paper, thesis and digital image processing book that study on the digital image segmentation on 2D images. It reviews the common image segmentation methods and software that commonly used.

Chapter 3 mainly describes the methodology, theory and approaches in completing the project. Design flow on the project is reviewed as well. Results and discussions are presented in chapter 4. The functionality of the options in GUI and the expected outcome are being discussed in this chapter. Lastly, Chapter 5 summarizes the entire project together with some suggestions for future works.

REFERENCES

1. D.J. Withey and Z.J. Koles (October 2007). Medical Image Segmentation: Methods and Software. *In proceeding of NFSI & ICFBI 2007*, Hangzhou, China. 1-4.
2. Rafael C. Gonzalez and Richard E. Woods (2010). *Digital Image Processing*. Third Edition. 711-809.
3. Dzung L. Pham, Chenyang Xu and Jerry L. Prince (January 1998). *A Survey of Current Methods in Medical Image Segmentation*. 6-10.
4. N. Senthilkumaran and R. Rajesh (May 2009). Edge Detection Techniques for Image Segmentation. *International Journal of Recent Trends in Engineering*, Vol. 1, No. 2. 250-254.
5. Nassir Salman (April 2006). *Image Segmentation Based on Watershed and Edge Detection Techniques*. 104-109.
6. Felicia S. Jones (2003). *Medical Image Segmentation*. The University of Georgia, Athens. 8-70.
7. V. Grau, A. U. J. Mewes, M. Alcañiz, R. Kikinis and S. K. Warfield (April 2004). Improved Watershed Transform for Medical Image Segmentation Using Prior Information. *IEEE Transactions on Medical Imaging*, Vol. 23, No. 4. 447-457.
8. Larry Reinking (June 2007). *ImageJ Basics (Version 1.38)*.1-3.
9. Larry Reinking (June 2007). *Examples of Image Analysis Using ImageJ*. 1-2.
10. Christoph Sommer, Christoph Straehle, Ullrich Kothe, Fred A. Hamprecht (2011). *ILASTIK: Interactive Learning and Segmentation Toolkit*. 230-233.
11. Ivan Graham (February 2005). *MATLAB Manual And Introductory Tutorials*. 1-30.
12. The MathWorks, Inc (December 1996). *Building GUIs with MATLAB (Version 5)*. 1-88.
13. Suman Tatiraju and Avi Mehta. *Image Segmentation using k-means clustering, EM and Normalized Cuts*.1-7.

14. Ch.Hima Bindu, Qiscet, Ongole (2009). An Improved Medical Segmentation Algorithm using Otsu Method. *International Journal of Recent Trends in Engineering*, Vol 2, No. 3. 88-90.
15. Ching Yee Yong, Kim Mey Chew, Nasrul Humaimi Mahmood and Ismail Ariffin (2012). *A Survey of Image Processing Tools Package in Medical Imaging*. 48-52.
16. Dr. Michael, Dr. Paulo and Dr. Sunanda (2004). *Image Processing with ImageJ*. 36-42.
17. DuSan Heric, Boiidar PotoEnik (July 2003). *An Image Segmentation Tool (IST)*. 483-488.
18. Alaa Sheta, Malik S. Braik and Sultan Aljahdali (2012). *Genetic Algorithms: A Tool for Image Segmentation*. 1-7.
19. Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins (2009). *Digital Image Processing Using MATLAB (Second Edition)*. 13-50
20. John Ashburner, Gareth Barnes and the FIL Methods Group (February 2012). *SPM8 Manual*. 43-49.