LAND COVER CHANGE DETECTION BY USING UNMANNED AERIAL VEHICLE (UAV) IMAGES

LEE YEN FEN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS TESIS

JUDUL: LAND COVER CHANGE DETECTION BY USING UNMANNED AERIAL VEHICLE (UAV) IMAGES

SESI PENGAJIAN: 2015/2016

Saya LEE YEN FEN

(HURUF BESAR)

mengaku membenarkan tesis (PSM/~~Sarjana~~/~~Doktor Falsafah~~) ini disimpan di Perpustakaan

Fakulti Teknologi Maklumat dan Komunikasi dengan syarat-syarat kegunaan seperti berikut:

1. Tesis dan projek adalah hakmilik Universiti Teknikal Malaysia Melaka.

2. Perpustakaan Fakulti Teknologi Maklumat dan Komunikasi dibenarkan membuat salinan untuk tujuan pengajian sahaja.

3. Perpustakaan Fakulti Teknologi Maklumat dan Komunikasi dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.

4. ** Sila tandakan (/)

______	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
______	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan dimana penyelidikan dijalankan)
/	TIDAK TERHAD	

(TANDATANGAN PENULIS)	(TANDATANGAN PENYELIA)
Alamat tetap: 37-G,JLN TTP 12, TMN TASIK PUCHONG,47120 SELANGOR	Nama Penyelia: PROFESOR MADYA DR ASMALA AHMAD
Tarikh: 16/8/2016	Tarikh: 16/8/2016

CATATAN: *Tesis dimaksudkan sebagai Laporan Projek Sarjana Muda (PSM)

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa.

LAND COVER CHANGE DETECTION BY USING UNMANNED AERIAL VEHICLE (UAV) IMAGES

LEE YEN FEN

This report is submitted in partial fulfilment of the requirements for the Bachelor of Computer Science (Artificial Intelligence) with Honours

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA 2016

DECLARATION

I hereby declare that this project report entitled

LAND COVER CHANGE DETECTION BY USING UNMANNED AERIAL VEHICLE (UAV) IMAGES

is written by me and is my own effort and that no part has been plagiarized without citations.

STUDENT:____ Date: 16/8/2016

(LEE YEN FEN)

I hereby declare that I have read this project report and found this project report is sufficient in term of the scope and quality for the award of Bachelor of Computer Science ((Artificial Intelligence)) With Honours.

SUPERVISOR:____ Date: 16/8/2016

(PROFESOR MADYA DR ASMALA AHMAD)

DEDICATION

I dedicate my final year project report to my family and friends. To my supervisor, Professor Madya Dr Asmala Ahmad, for guiding and helping e to finish up this project. I would like to express deep gratitude to my beloved parents for a life-long love and affection. They have been very supportive and encoring completion of my thesis and throughout the years of my studies. On top that, I also would like to dedicate this report to my close friends and family who have been very supportive throughout the project development.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor, Profesor Madya Dr Asmala Ahmad, for the patient guidance, encouragement and advice he has provided throughout our time as his student. I have been extremely lucky to have a lecturer who cared so much about our work, and who responded to all my questions and queries so promptly. Besides that, I also would like to thank to my parents for being so supportive and helped me a lot in term of moral support. Lastly, I would like to thank to my course mate and all those who supported me in any aspect throughout the project.

ABSTRACT

The project was implemented by using the Unmanned Aerial Vehicle (UAV) images. The area of study of this project was in University Technical Malaysia Malacca, Malacca (UTeM). The objective of doing this project is to develop land cover change detection procedure using images recorded from UAV. Image subtraction method was used to detect the changes happen in UTeM. It is used the concept of different between two images by pixel-by-pixel subtraction to find the changes. Envi software was used to do the preprocessing such as image registration and image subset/resize while Matlab software was used to implement the image subtraction algorithm to find the changes happen. The methodology of the project consist of 5 phases which are phase 1 - analysis the problem and method used before, phase 2 – design a suitable method and procedure to obtain change detection, phase 3 – implementation the designed method to produce the output,phase 4 - testing and evaluate the results and outputs obtained and lastly, phase 5 - conclusion.

ABSTRAK

Projek ini telah dilaksanakan dengan menggunakan imej tanpa pemandu (UAV). Kawasan kajian projek ini adalah di Universiti Teknikal Malaysia Melaka, Melaka (UTeM). Objektif melakukan projek ini adalah untuk membangunkan prosedur pengesanan tanah perubahan menggunakan imej yang dirakam menggunakan UAV. Kaedah penolakan imej telah digunakan untuk mengesan perubahan berlaku di UTeM. Ia menggunakan konsep yang berbeza antara dua imej dengan pixel demi piksel penolakan untuk mencari perubahan. Perisian ENVI telah digunakan untuk melakukan rawatan awal seperti pendaftaran imej dan subset image / mengubah saiz manakala perisian Matlab telah digunakan untuk melaksanakan algoritma imej penolakan untuk mencari perubahan berlaku. Metodologi projek ini terdiri daripada 5 fasa iaitu fasa 1 - analisis masalah dan kaedah yang digunakan sebelum ini, fasa 2 - mereka bentuk kaedah yang sesuai dan prosedur untuk mendapatkan pengesanan perubahan, fasa 3 - pelaksanaan kaedah yang direka untuk menghasilkan output, fasa 4 - menguji dan menilai keputusan dan output diperolehi dan akhir sekali, fasa 5 - kesimpulan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UAV	Unmanned Aerial Vehicles
SVM	Support Vector Machine
UTeM	University Technical Malaysia Malacca
ENVI	Environment For Visualizing Image
CVA	Changes Vector Analysis
MRF	Markov Random Field
GCP	Ground Control Points
GPS	Global Position System
RMS	Root-Mean-Square

LIST OF ATTACHMENTS

CHAPTER I

INTRODUCTION

1.1 Introduction

With the development of society and technology, human resource development and capacity to transform nature growing, variations and human activities are changing the nature of the daily landscape and land use in the form of the surface. Rapid world population growth and urbanization, accelerate the speed of the land change. These changes will have a profound impact on the earth's resources and the ecological environment has attracted widespread attention. The issue of land use and land cover change has become a global topic to consider and study. The use of remote sensing have the characteristic with fast, wide coverage, multi-spectral, periodicity and other has become one of the most important technical to implement in this studies.

For the last 20 years, researchers have developed several of change detection method based on remote sensing technology, there have been different classification methods can be roughly summarized as three main method, Image subtraction method, Image ratio method, and the method of change detection after classification (Xu et al., 2009). Furthermore, with increasing complexity and change diversity of land covers, the new change detection method and a new image processing algorithms are emerging, for example, changes vector analysis (CVA), Markov random field (MRF) models change detection, the use of probability polygon statistical theory based change detection method using a support vector machine (SVM), and object-oriented based change detection. In short, a number of research and practice has proved that there is no method which is generally considered the best, since most of these methods are in different environments based on different uses proposed, each having a different applicability and limitations.

1.2 Problem statement

Currently, the land cover change detection technique using satellite remote sensing still under research and study. Although there have many research and studies in satellite remote sensing area, due to the satellite remote sensing itself is affected by atmospheric conditions to a large extent, there are no way to ensure the quality of the image obtained, which in turn will affect the accuracy of the calculation results of the for change detection. Besides that the spatial and temporal resolution of satellite remote sensing images are unable to meet research needs for certain cases. In response to this situation, unmanned aerial vehicles (UAV) images was introduced. The special characteristics of UAV which is low in cost but high in spatial resolution output. However, the uses of UAV images are still not widely use in the change detection applications. In this project, the use of UAV images is proposed for the data for change detection to achieved better result.

1.3 Objective

This project aims to develop land cover change detection procedure using images recorded from UAV. In achieving this aim, the specific objectives are:

(i) To investigate the technique of land cover change detection using remote sensing platform.

(ii) To design and develop land cover change detection technique using UAV.

(iii) To evaluate and test the developed technique using suitable analysis.

1.4. Scope

In this project, the scope can be divided in three parts:

1.4.1 Software Scope

- Windows Operating System
- MATLAB R2015
- ENVI 4.5

1.4.2 Area of Project Scope

In this project, the area of project is in University Technical Malaysia Malacca (UTeM) Main Campus which located at Durian Tunggal, Melaka. It is located on latitude of 2.3139° N and 102.3212° E. The date of two set UAV imaged was 8 Jun 2015 and 27 March 2016. This aims to develop a technique to detect the land cover changes happen in UTeM using UAV images recorded at different time.

Figure 1.1: UTeM Maps（Google Maps）

1.4.2 User Scope

i) Researcher - The result of this project can be used as references materials in the field of remote sensing.

ii) Student and lecturer - The result can provide some useful information at the education field.

1.5. Project Significance

This research project is expected to produce the method or technique for land cover change detection by using the UAV images. This project would be beneficial to researchers who involved in the field of UAV remote sensing. This project is expected to provide baseline information on the project on changes detection using UAV images. Furthermore, this project would be beneficial to lecturers and students and will provide useful information which can be used in the learning process. To the future researchers, the outcomes of this project will also benefit government and private sectors who use UAV operationally.

1.6 Expected Output

The expected result is the technique that can detect the land cover change detection of from UAV images is obtained. The result obtained can provide the information of land cover changes such as the area of changes from the UAV images and this will bring a lot of convenience for the users to know the changes happen at the specific places.

1.7 Conclusion

As a conclusion, this project aims to detect the land cover changes in UTeM by using the UAV images. The changed detection algorithm will apply to determine the changes between UAV images. To achieve the objective of this project in the Chapter 1, the literature review and analysis will be explained in Chapter 2. This is followed by methodology and design in Chapter 3 and in Chapter 4 covers implementation which is then followed by testing and conclusion in Chapter 5 and 6 respectively.

CHAPTER II

LITERATURE REVIEW AND ANALYSIS

2.1 Introduction

In this chapter, the review for previous researches on the related topic and field is explained. Literature review is very important for this project because it can provide the guidance to propose the method used in land cover change detection. Through the study of the journals and research papers that have studied, this project will be assisted in writing to get the clearer understanding for the topic of the project.

This chapter also include the analysis phases. Analysis is very important phase to help to figure out the clearer view of change detection project. The analysis start with the discussion of the problem analysis to identify the problem of previous research method and follow by the overall analysis of the project.

2.2 Remote sensing

Land cover is constantly changing, many research have been conducted to identify the land cover change detection. There are a plenty of techniques used can be used to identify the differences. For example image differencing, image overlay, image rationing, classification comparison, principal component analysis, and the change vector analysis. (Kressler & Steinnocher, (1996) cited in Jensen. (1986)).In this project, the main objective is introduces the method to detect the changes happen in UTeM using the UAV images.

Remote sensing technology is a technology that using remote sensor from the aircraft, spacecraft, satellites, and others platform, through photography, scanning, sensor information to obtain information needed. At 1960’s, the word of "remote sensing" was first introduced, in the years of 1972, United States Landsat Program launched the first earth observation satellite. After several years of development, remote sensing technology has been widely used in military, defence, agriculture, forestry, land, ocean, mapping, meteorology, environment, water conservation, aerospace, geology, mining, archaeology, tourism and other areas. Now the application of remote sensing technology is much broader and deeper.

2.3 Unmanned aerial vehicles (UAV)

UAV remote sensing technology is a comprehensive utilization of advanced unmanned aerial vehicle technology with automation, intelligent, dedicated quick access to the land. UAV remote sensing is another popular choice of platform others than satellite remote sensing in photogrammetry technology due to it some unique advantages.

2.3.1 High flexibility and reliability

The most significant advantage of UAV is having high flexibility either in the hardware and the algorithm development. This is because an own developed system definitely easier to control and manipulated than others aerial platform such as satellite.

2.3.2 Responsive, efficient operation

After receiving aerial tasks, the system can be done quickly dispatched, quick access, fast processing, rapid analysis of discrimination, have a short cycle diagram, aging, and other characteristics. A UAV in a single day can 100-200km2 regional remote sensing operations, greatly improving the efficiency of monitoring.

2.3.3 Ability to obtain high-resolution aerial imagery

The system is capable of high resolution image acquisition, image color is rich, clear and intuitive, accurate and able to meet the large scale mapping, ground class discrimination, watershed information extraction, etc. UAV image resolution is better than most of the current domestic and international high-resolution satellite images.

Figure 2.1: UAV (Best Quadcopters | Quadcopter Reviews | RC Quadcopters for Sale | Drones, *2016*)

2.4 Change Detection

Change detection can be defined as the process of identifying differences of the surface changes of an object or phenomenon by observing it at different periods. (Singh, 1989). Change detection is a quantitative analysis and determine changes in surface features and processes. In short, change detection can explain in there have two images of the same area at different times to provide information for analysis, processing and comparison, obtaining the period of land use and cover change information. From a technical point of view the process in general, including image pre-processing, change information discovery, change and variation type determination region extraction several processes in the image pre-processing is complete, the remaining key change information is found that most studies have been the link carried around. According to Xu et.al (2009), change detection method currently divided into three main categories: Image subtraction method; Image ratio method; Change detection based image classification.

2.5 Facts and findings

There are several of researcher doing the research on land cover change detection. Detailed reviews of their works are given as follows:

The Comparative Study of Three Methods of Remote Sensing Image Change Detection

Xu et.al (2009) compared the different among the method of image subtraction, image ratio and change detection after classification. This three method are the mainly used in change detection. They compared the three method by different perspective. First from the accuracy perspective, the accuracy of image ratio is the most high, then is image subtraction and lastly is change detection after classification. Then from the view of operational perspective, the method of change detection after classification is the worse compared to others as it more complex and take longer time to accomplish. While from the application perspective, image ratio method can provide the details and information of change detection such as analysis of soil and vegetation however the others two method fails to provide it. After compared the three method in different perspectives, they claimed that the change detection method is very difficult to evaluate precisely as different method having its own advantages and disadvantages except using the visual method. However visual method having subjective error.

Evaluation of Change Detection Techniques for Monitoring Land-Cover Changes: A Case Study in New Burg El-Arab Area

Afify (2011) carried out an experiment to evaluate the land cover change detection method in New Burg El-Arab area from 1990 to 2000. In the experiment, he use four different method which are post-classification, image differencing, image rationing and principal component analysis(PCA) to do the experiment and evaluate each performance using overall accuracy of the change/unchanged and classified change images of the four change detection techniques. The post classification technique provide the highest overall accuracy (73.90%, 66.70%)for the result of change/unchanged and classified change images while the principal component method provide the worst accuracy(53.57%, 47.63%) and the accuracy of image rationing(64.80%, 57.04%) and image differencing techniques(60.00%, 53.56%) are not much different. He explained that these accuracy are mainly dependent to the accuracy of initial classification into two images. While the post-classification is more straight forward technique compared to others three especially PCA which requires more processing step before apply the detection technique. And errors occur when during these possessing step causing the overall accuracy decreases. He found that the overall accuracy of four change detection technique is much better than the classified change image because of the errors in the “from–to” classification process. This paper is very useful to help to identify which methods to choose when in land cover change detection area.

Change detection from remotely sensed images: From pixel-based to object-based approaches

Hussain, Chen, Cheng, Wei and Stanley (2013) studied the traditionally pixel-based and statistics-oriented change detection techniques which focus mainly on the spectral values and mostly ignore the spatial context. In the studies, they try to review and highlighted the functionalities and limitation from pixel-based change detection to object-based change detection method. Due to the increasing amount of very high resolution images captured and processed, challenges arise on how to improve the traditional image analysis techniques. Object based image analysis technique is introduced to handle the large variations in very-high-resolution images and to get better accuracy both in image. Comparing to pixel-based approaches, object based change detection facilitate with the multi-scale analysis to allow delineating landscape features at different levels, and reduces the small spurious changes. And with the increasing availability of large multi-scale multisensory multi-temporal remotely sensed datasets the data mining techniques have shown their potential in remote sensing change detection. The data mining techniques can help improve the classification results when objects are used by exploring different characteristics and understanding the complex relationships. They claims that there is no single approach optimal and applicable to all cases. It is no wonder that a large number of change detection techniques from remotely sensed images have been developed, and new techniques and methods are still emerging. Although the outcomes are quite promising, the main shortcoming is the lack of concrete reason and experimenter result to support their point of view.

Analysis of Land Use/Land Cover Changes Using Remote Sensing Data and GIS at an Urban Area, Tirupati, India

Mallupattu and Sreenivasula Reddy (2013) carried an experiment in Tirupati, India to analysis the land use and land cover changes. Before do post classification comparison, they done some pre-processing and classification of the obtained satellite imagery. The satellite images was enhanced by using histogram equalization in ERDAS Imagine 8.7 to improve the quality of the image so that can achieve better result of classification. In this experiment, they proved that integration of Geographical Information Systems GIS and remote sensing technologies is effective tool for urban planning and management. The result of this paper is good and useful however the result only applicable for post classification because the result of land cover use accuracy does not compare with others methods.

Land-Use/Land-Cover Change Detection Using Improved Change-Vector Analysis

Chen, Gong, He, Pu and Shi (2003) introduced the land use/land cover change detection by using change vector analysis (CVA) method. The method work by determine the threshold value of changes in magnitude and type discrimination. They implement this technique in detection of land cover changes in Hai din District, Beijing, China. From the experiment, they found out that the performance result by CVA have improved as the Kappa coefficient of change/unchanged and “from-to” classification increases for all kind of land cover changes compared with the method of post classification. The study show that the CVA method is better than post classification.

Support Vector Machine Classification to Detect Land Cover Changes in Halabja City, Iraq

Al-Doski et.al (2013) proposed using the support vector machine supervised classification technique in the processing step to extract useful information from satellite data before undergo the post classification change detection method. They applying SVM supervised classification algorithm to determine the land cover changes occur in Halabja, Iraq. The overall accuracy of changes was 93% with Kappa coefficient 0.85. They claimed that the high performance of SVM classification and post classification are ideal to apply for the research of land cover change detection. The study show that applying SVM algorithm in image classification before the change detection can improved the overall performance but the study need to be further explore as this study only applicable in post classification change detection technique.

2.6 Analysis

In this section, the analysis phase is explained in detail. In this phase, requirement analysis process is done for getting the knowledge to the problem statement. It begins by first analysing the problem and then followed by others requirement analysis.

2.6.1 Problem Analysis

UAV images is becoming one of the most important platform in remote sensing area as it has a more flexible operation, higher resolution, and lesser affected by the weather compared to conventional platforms. In this land cover change detection study, UAV images was chosen to be used as the input of the study. First of all, before the change detection processing, filter all images that have been taken by UAV by different time interval. The filtered images was going some pre-processing to achieve some of the requirement that before implement the change detection technique. In between, the UTeM region was selected to become the study area of this change detection project as want to know the changing happen inside UTeM. After the study of change detection in UTeM, the output will be useful for the end user.

2.6.2 Data Requirement

In this study, a UAV of Walkera QR X800 model was used to collect the UAV imagery. This model of UAV is equipped with brushless motors powered by a battery and can fly by remote control or autonomously with the aid of its Global Position System (GPS) receiver and its waypoint navigation system. The latitude, longitude, altitude and other information of the current location of the images can be recorded during data acquisitions process. A mission planning must done before the data acquisitions process.

UAV mission planning is based on the tasks to be completed, work out the flight path, strategies and emergency backup solution and build the flight control instruction. UAV mission planning functions include:

a) route planning functions

Decide when the UAV should taking off and landing, closer to the monitoring point reconnaissance to the monitoring area, leave the monitoring points. Furthermore, route planning function also will provide some emergency or backup solution for every route that it plan.

b) trajectory generation

Can generate commonly used standard flight path such as round shape, 8-shaped spiral, rectilinear, etc., and stored it in the database as an orbit. When during the flight, the stored orbit can be entered and edited manually according to the requirement of the task.

c) Regular flight route generation

Management features, can search to a particular area of a regular flight route, stored in the library of regular routes. The library routes will be consider all the characteristics of the sensor, the sensor search mode and the sensor viewing direction, and other factors to achieve the target the best reconnaissance.

d) Capabilities of flight simulation presentation

The feasibility of the aircraft flight simulation, test flight altitude, fuel consumption and other indicators flight can be superimposed on a digital map during the flight.

e) Capabilities of reconnaissance demonstration effect simulation

Patrols in different locations and different altitudes can be calculated based on digital map image shown, and this enables the operator to select the best solution for mission

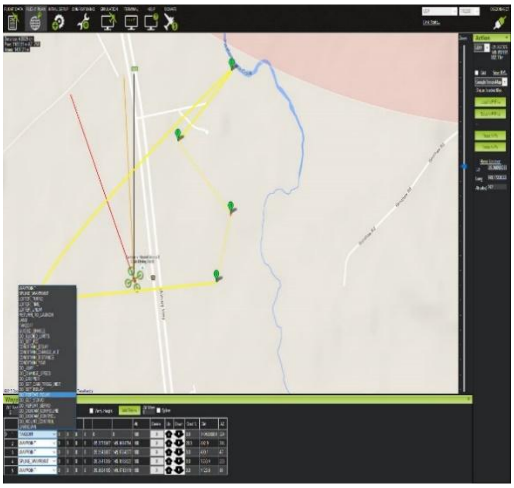

Figure 2.2: Mission Planner: Flight Plan Screen (a)

Figure 2.3: Mission Planner: Flight Plan Screen (b)

2.6.3 Software requirement

The software used in this study was shown in the table below:

Table 2.1: Software requirement

Requirement	Use
ENVI 4.5	Used for pre-processing and change detection process.
MATLAB R2015	Used for change detection process.

2.6.4 Hardware requirement

The hardware used in this study was WALKERA QR X800 matched with DEVO F12E controller and two canon camera. The list of these hardware specification shown in tables below:

Table 2.2: Specification of QR X800

Basic parameters	Main Controller	FCS800
	Brushless Motor	WK-WS-48-001
	Brushless ESC	WK-WST-60A-6
	Receiver	Receiver RX704
	Transmitter	DEVO 12E/F12
	Battery	22.2V 10000-15000mAH
	Diameter of the main wing	1200mm
	Length of the main wing	400mm
	Overall (L x W x H)	620 x 620 x 400 mm
	Take-off Weight	<4000g
	Image transmission distance	500m-1km
	Control distance of DEVO 12E / F12	1.5-2km

Table 2.3: Specification of Canon PowerShot SX260 HS and Canon PowerShot S100

	PowerShot SX260 HS	Canon PowerShot S100
Processor	DIGIC 5	DIGIC 5
Lens max aperture range	F3.5 - F6.8	F2–F5.9

Lens focal range (35mm equiv.)	25 - 500 mm (20X)	24–120 mm(5X)
Intelligent IS	Yes	Yes
LCD aspect ratio	Normal (4:3)	1:1, 5:4, 4:3, 3:2, 16:9
Burst rate (full res)	10.3 frames/sec	8 frames/sec
Flash working range (Auto ISO)	0.5 - 3.5 m (W) 1.0 - 2.0 m (T)	0.5 - 7.0 m (W) 0.5 - 2.3 m (T)
Smart Auto scenes	58	32
Face ID (recognition)	Yes	Yes
Live View Control mode	Yes	Yes
Battery used	NB-6L	NB-5L
Battery life (CIPA)	230 shots	200 shots
Dimensions	4.2 x 2.4 x 1.3 in.	3.9 x 2.36 x 1.1 in.
Weight (body only, empty)	208 g	198 g
Built-in GPS	Yes	Yes

2.7 Conclusion

As a summary, this chapter has discussed the review of related works and also the analysis requirement for the project. In this chapter, all the functional methods and algorithms have been explained and the next chapter will continue on the methodology and design of the project.

CHAPTER III

METHODOLOGY AND DESIGN

3.1 Introduction

In this chapter, the method used to achieve the objective of the study is explained in detail. There are 5 phases which are phase 1 - analysis the problem and method used before, phase 2 – design a suitable method and procedure to obtain change detection, phase 3 – implementation the designed method to produce the output,phase 4 - testing and evaluate the results and outputs obtained and lastly, phase 5 - conclusion.

On the others hand, in this chapter also cover the explanation of the design for the output of change detection using the UAV images. During the process of design the study of the change detection, there are a lot of methodological decisions required to make as the every decision and method chosen will affected every single result of the study. Every input image will undergoes some process to produce the final output for the change detection purpose.

3.2 Phases

To achieve the objectives of the project, there are five phases involved in completing the project.

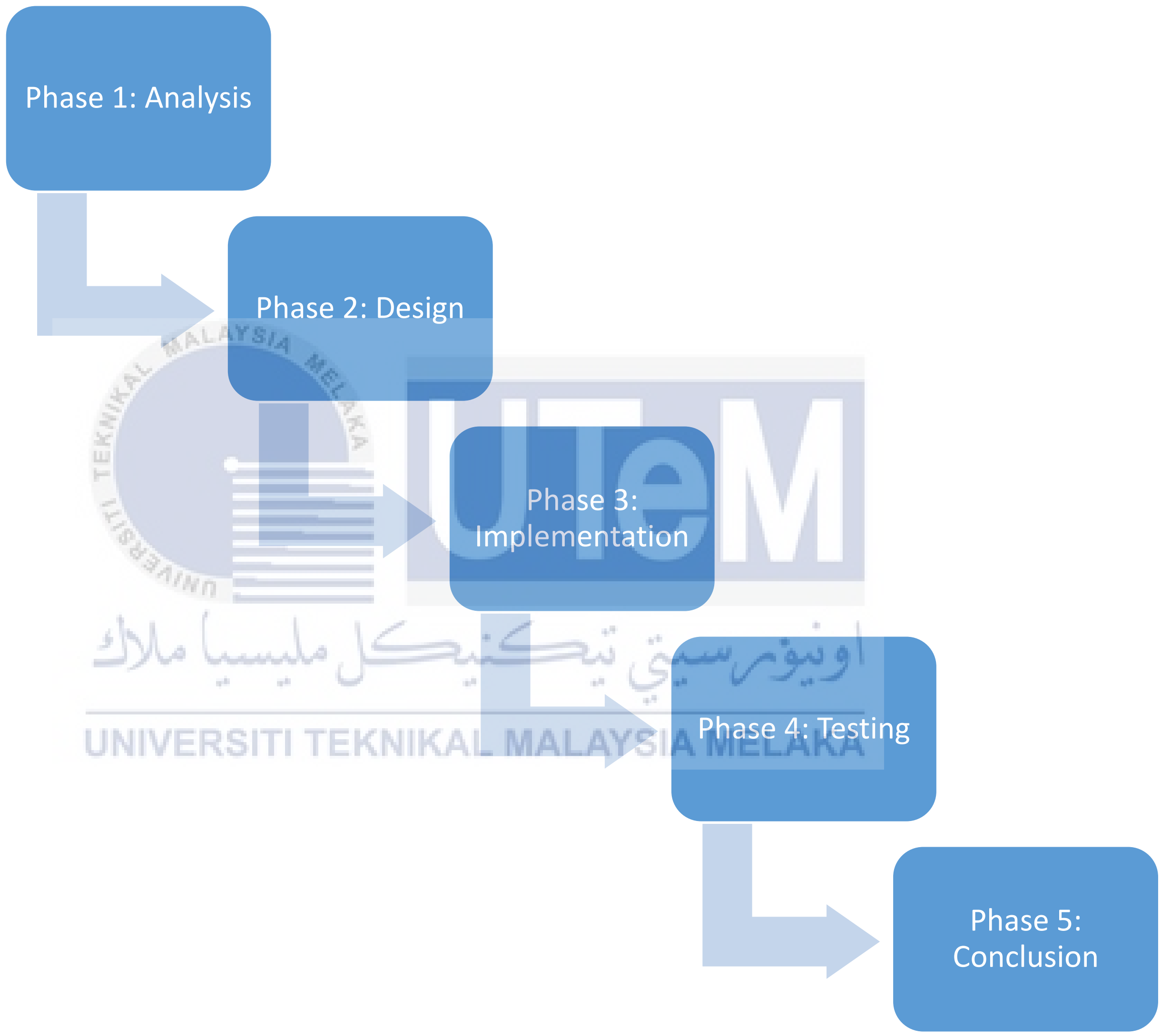

Figure 3.1: Phases of project

Phase 1: Analysis

First, study the existing method and technique to understand the concept of change detection and get some knowledge to the problem statement. Then the objectives and scopes of the project are developed based on the analysis of the previous methods and techniques.

Phase 2: Design

In this phase, a suitable method and technique for change detection are designed and developed based on the problem statements of the project.

Phase 3: Implementation

After the design phase, implementation process is continued to produce all the final result from design phase.

Phase 4: Testing

The fourth stage of the model is testing. After getting all the final results, the results are tested to get the performance and compare the result to the previous method and technique.

Phase 5: Conclusion

The last stage is making the conclusion for all the phases, and discussing the strength and weakness of the study besides proposing suggestions for future research.

3.3 Project Schedule and Milestones

The table below shows the milestone throughout the change detection project.

Table 3.1: Milestone of Final Year Project 2016/2017

Week	Activity
22-26 Feb	Proposal PSM : Submission & Presentation
	Proposal assess4ment and verification
29 Feb -4 Mar	Proposal Correction/Improvement Chapter 1
7-11 Mar	Preparation of Chapter 1
14-18 Mar	Preparation of Chapter 1 & Chapter 2
21 - 25 Mar	Preparation of Chapter 2
28 Mar -1 April	Deliverable of Chapter 2 & Preparation of Chapter 3
4-8 April	Project Demo & Deliverable of Chapter 3 Preparation of Chapter 4
	MID SEMESTER BREAK
18-22 April	Project Demo & Preparation of Chapter 4
25 - 29 April	Project Demo & Deliverable of Chapter 4
2 - 6 May	Project Demo
9 – 13 May	Project Demo & preparation of PSM Report

16 - 20 May	Project Demo & Preparation of PSM Report
	Presentation
23 - 27 May	Project Demo & PSM Report
30 May -3 June	**FINAL PRESENTATION**
6 - 10 June	**REVISION WEEK**
	FINAL EXAMINATION SEMESTER
27 June -8 July	Preparation of Chapter 5
11 - 22July	Correction of Chapter 5
25 July-29 July	Deliverable of Chapter 5 & preparation of Chapter 6
1 - 6 August	Drafting full report
8 -12 August	Deliverable full report
15 -19 August	Presentation and report correction

3.4 Design

In this part, the process and procedure of determining land cover change detection will be explained in detail. Before the processing to change detection, there are several pre-processing steps need to be completed to achieve the requirement of the study. Each output of the pre-process will be used as the input for next stage and enhanced to obtain better result.

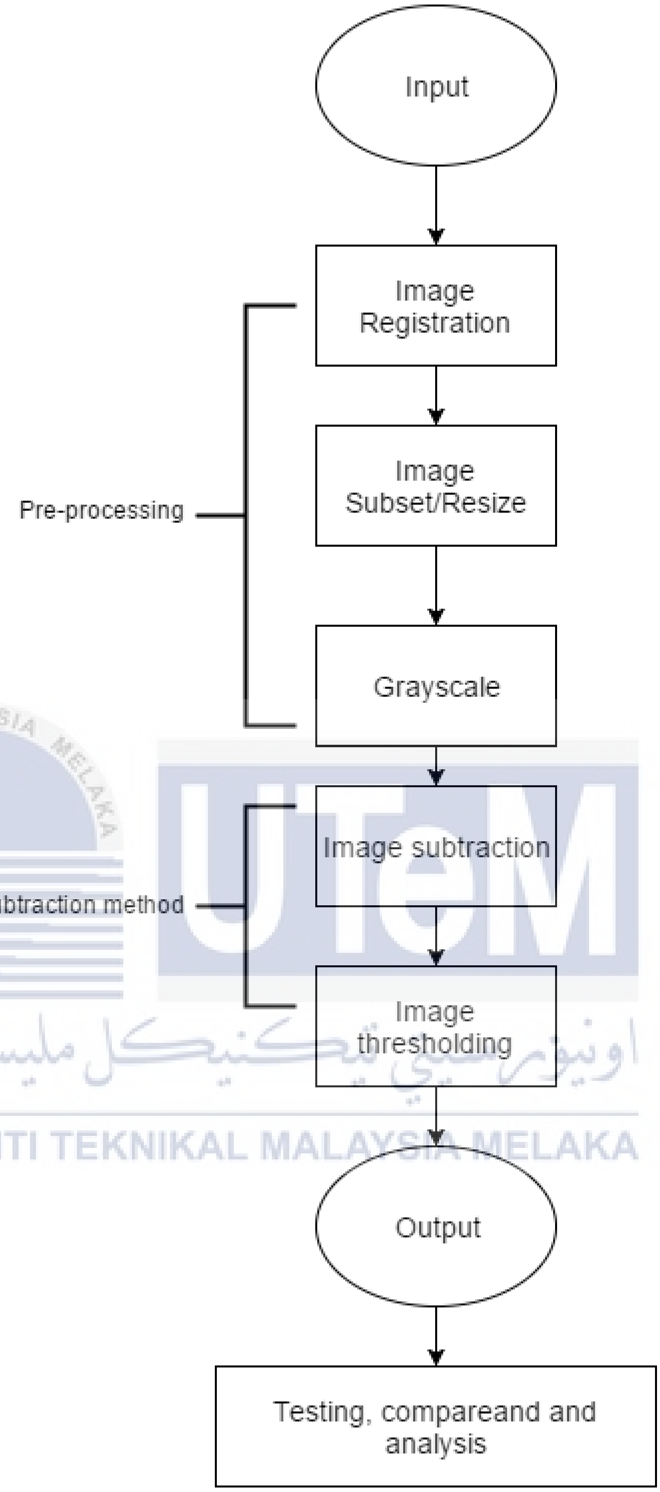

Figure 3.2: Image Subtraction Process

3.4.1 Input

The primary input of this study are the images acquired by a UAV of WALKERA QR X800 model. The area that have been choosen for this study is UTeM which located on latitude of 2.3139° N and 102.3212° E. At least two set of images are required to demonstrate the change detection. The images were taken on 8 Jun 2015 and 27 March 2016 in which having the interval range about 9 month differences.

3.4.2 Image Registration

Image registration is a process geometrically aligning two or more images to integrate or fuse corresponding pixels that represent the same objects, same feature or landmark in the images.

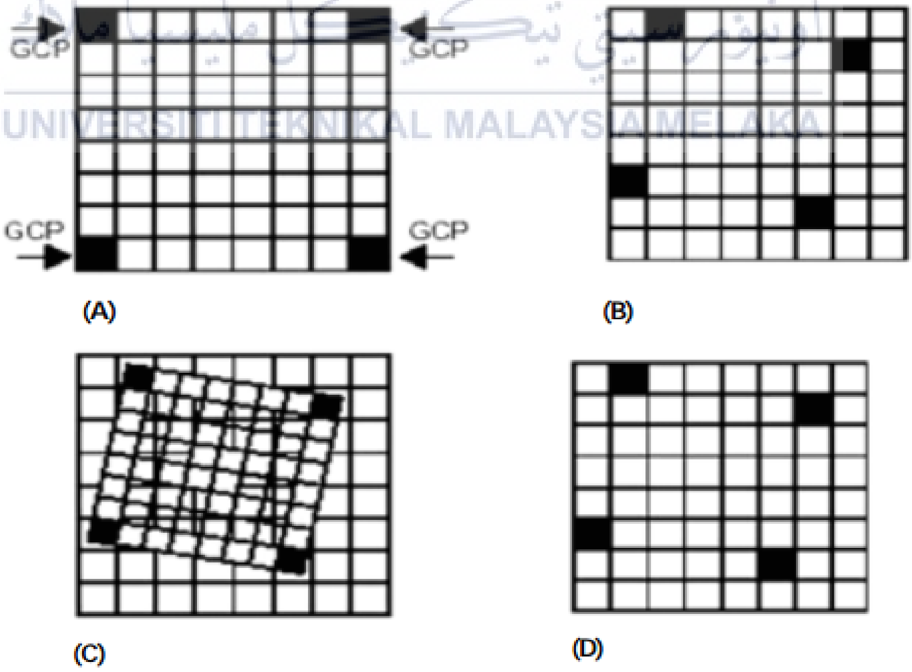

Figure 3.3: Concept of image registration

The figure above shows the concept of image registration where A and B are two input image. B as the base image and A be the image to be register base on B. C show the process of mapping two image of A and B with the common point or Ground control points (GCP). GCP are locations on the surface of our planet with a known X/Y (e.g. latitude and longitude) and Z (e.g. height above mean sea level in meters). After the process of C, the initial image A will become same as D. Now the B and D is two image which have registered.

3.4.3 Image Subset/Resize

In the image subset phase, the UAV images were resized to the area of interest. Spatial subset method was chosen in this project.

3.4.4 Greyscale

Greyscale conversion is done for the purpose of converting a three dimensional matrix (RGB/color image) to one dimensional matrix (grey scale image) which the pixel values ranging from 0 to 255.where 0 represent the black color and 255 represent white color. This process is required before implementing the image subtraction method.

3.4.5 Image subtraction

Image subtraction is the most widely used method in remote sensing change detection. It is based on pixel-by-pixel subtraction to determine the differences between two images by. In this project, the two images of the same area, obtained from times t_1 and t_2, are subtracted pixel wise. Mathematically, the difference image is

$$X_d\,(i, j) = X_1(i, j) - X_2(i, j),$$

where X_1 and X_2 are the images obtained from t_1 and t_2, (i, j) are the coordinates of the pixels. The resulting image, X_d , represents the intensity difference of X_1 from X_2.

This technique works only if images are registered.

3.4.6 Image thresholding

Image thresholding is a process of isolates objects or other relevant information in digital images. In this project, the concept of replace each pixel in an image with a black pixel if the image intensity I {i, j} is less than or equal to some threshold value, or a white pixel if the image intensity is greater than the threshold value.

In this project, Otsu's method was chosen as the thresholding method. Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either fall in black or white. The aim is to find the threshold value where the intraclass variance of the black and white pixels is at its minimum.

3.4.7 Output

The output of this whole process will obtain and can manipulated the output to analyze to gain useful information. The result of this project will in the total change in pixel in m^2 and a histogram to show the changes between two images.

3.4.8 Testing, compare and analysis

In order to test the accuracy of image subtraction method for change detection algorithm in UAV images. The other pixel-based change detection algorithm, image ratioing method was used to compare the accuracy of image subtraction method.

Mathematically, the ratio of image is

$$X_d (i, j) = X_1(i, j) \div X_2(i, j),$$

where X_1 and X_2 are the images obtained from t_1 and t_2, (i, j) are the coordinates of the pixels. The value equal to 1 correspond to no change happen while others correspond to changes happen.

Generally the fundamental concept of image subtraction and image rationg are quite similar which manipulated the image arithmetic to show the changes pixel in two images. The different is just the way of thresholding the image to show the clearer changes happen in the image.

3.5 Conclusion

In conclusion, this chapter has explained the process of the overall project and the methodology used to complete the project. Each process is explained in detail and the next chapter will explain the result obtained.

CHAPTER IV

IMPLEMENTATION AND RESULTS

4.1 Introduction

This chapter explains the process of change detection that have been discussed in the previous chapter. In this chapter, the specific techniques and formula are described in detail. The combination of the results provide the insight and findings of the project outcomes.

4.2 Data prepossessing

The UAV images undergone several pre-processing stages before the proposed change detection techniques can be applied. The pre-processing stages are input data, image subset/resize, image registration and grayscale.

4.2.1 Input data process

The input data for this project are UAV images which were captured for the same location but at different dates. The UAV images is the image taken by using the unmanned aerial vehicle model of WALKERA QR X800. The phases of retrieved the images from the UAV is known as image acquisition. The figure below shows the flow of image acquisition.

Figure 4.1: UAV Image Acquisition Flow

Figure 4.2 and Figure 4.3 shown input data used in the project with different dates.

Figure 4.2: Input image at time 1

Figure 4.3: Input image at time 2

4.2.2 Image Registration

The two images taken in different times usually have some different in geometric error, i.e. errors due to random movement of the UAV, altitude (height above sea level) changes of the air or UAV and etc. will cause to different effect to the imagery. So, before applying the change detection method, the input image need to undergo image registration process. In this project, Image-to-image registration was chosen. The concept of image-to-image registration is that only one image is chosen to be the reference image. After that, the image is examined to find suitable GCPs (ground control points) locations. These GCPs can be adjusted accordingly based on the RMS (root-mean-square) errors shown (Figure 4.4) in ENVI 4.5. The RMS Error shown can used to judge the accuracy of your control points. The lower the RMS Error, the higher the accuracy of the point selected.

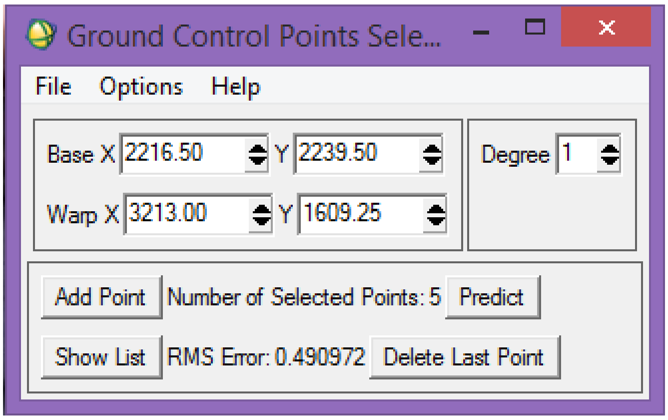

Figure 4.4: Ground Control Point Selected List

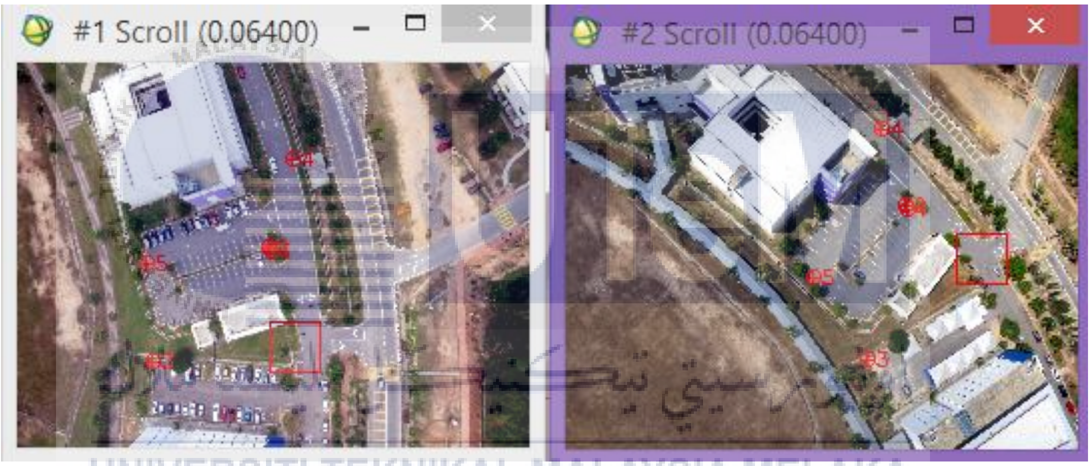

Figure 4.5: Sample GCP selected between two images

Figure 4.6 shows the base image and the Figure 4.7 shows the wrap image which is the output of registration based on the Ground Control Point (GCP).

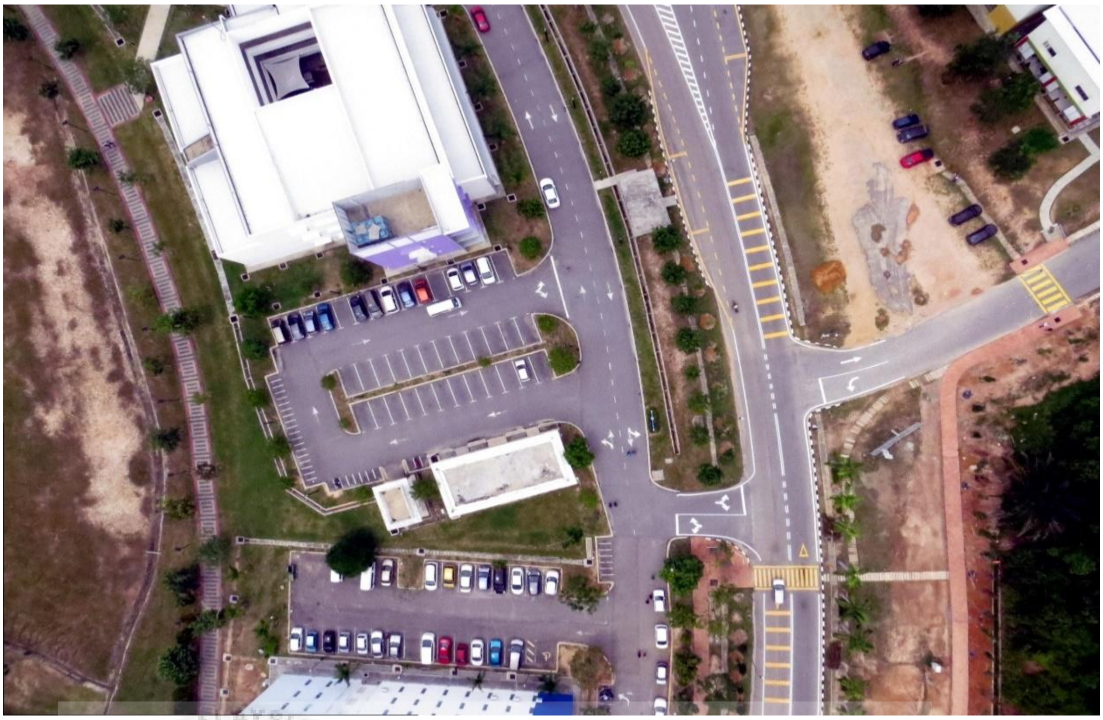

Figure 4.6: Base image

Figure 4.7: Wrap image

4.2.3 Image Subset/Resize

Image subset/resize is the process of selection the region of interest from large portion of image. There are two type of subset method in Envi 4.5 which is spatial subset and spectral subset. In the project, the image was subset using the spatial subset by images. Figure 4.8 shows the image shown in scroll window in Envi 4.5 and using bounding box to cut off the region of interest in the input image.

Figure 4.9 and Figure 4.10 show the results of image subset for two input images. UTeM was chosen as the area of study. The subset region involved the changes part.

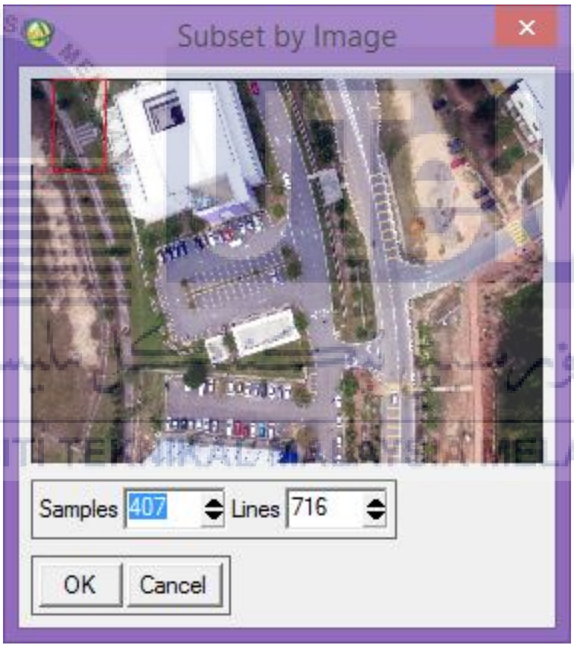

Figure 4.8: Spatial subset (subset by image)

Figure 4.9: Image after subset (input 1)

Figure 4.10: Image after subset (input 2)

4.2.4 Greyscale

In this project, the first layer of the RGB image is considered for carrying out the change detection. We converted the three dimensional image (RGB) to one dimensional image (greyscale) by using Matlab. Figure 4.11 and 4.12 show the results of greyscale after running in the Matlab tools.

Figure 4.11: Greyscale image (input 1)

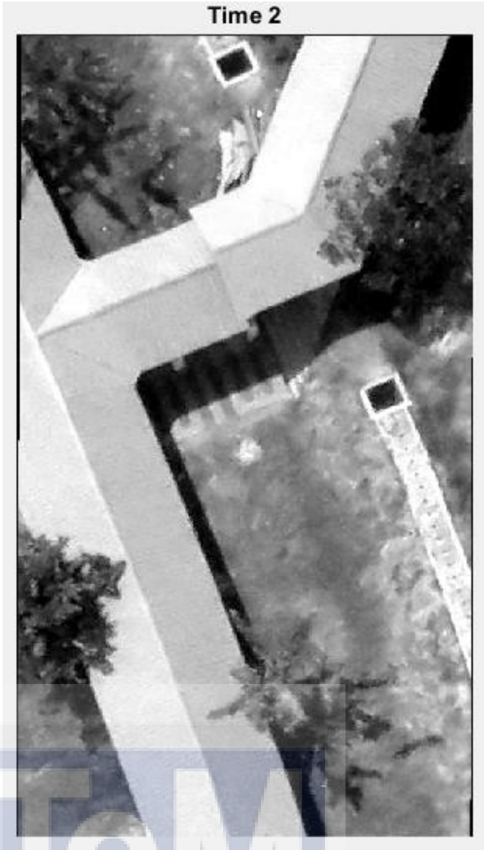

Figure 4.12: Greyscale image (input 2)

4.2.5 Image subtraction

A subtraction image is generated using image subtraction technique. This was done by subtracting an image with another image. The grey value of the subtraction image is to show the extent of changes of two images. The Figure 4.13 show the result of image subtraction which use the two input image Figure 4.11 and Figure 4.12 respectively.

Figure 4.13: Result of image subtraction

4.2.6 Image thresholding

After the image subtraction, the result cannot show clearly the changes that have occurred from the Figure 4.13 above. Therefore, image thresholding is required after undergo the image subtraction process. The result obtained in image subtraction will be automatically classified into two group which is black colour (0 value) and white colour (255 value) by Otsu’s thresholding method. The black colour represents no changes while the white colour represents changes in the image. Figure 4.14 is the output after image thresholding.

Figure 4.14: Result of Image thresholding

4.2.7 Output

In an image processing context, the histogram of an image normally refers to a histogram of the pixel intensity values. This histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. For an 8-bit greyscale image there are 255 different possible intensities, and so the histogram will graphically display 255 numbers showing the distribution of pixels amongst those greyscale values.

From figure 4.15, the histogram shows that most of the pixel fall into low intensity or more toward to the dark pixel which mean after image subtraction of two year UAV image there are no change in generally. However, there minor values lies on toward high intensity .This state that there some object are added which made change detection happen. It is true that the minor values lie high intensity of histograms is new corridor and building has been built as show in Figure 4.2 and 4.3 above.

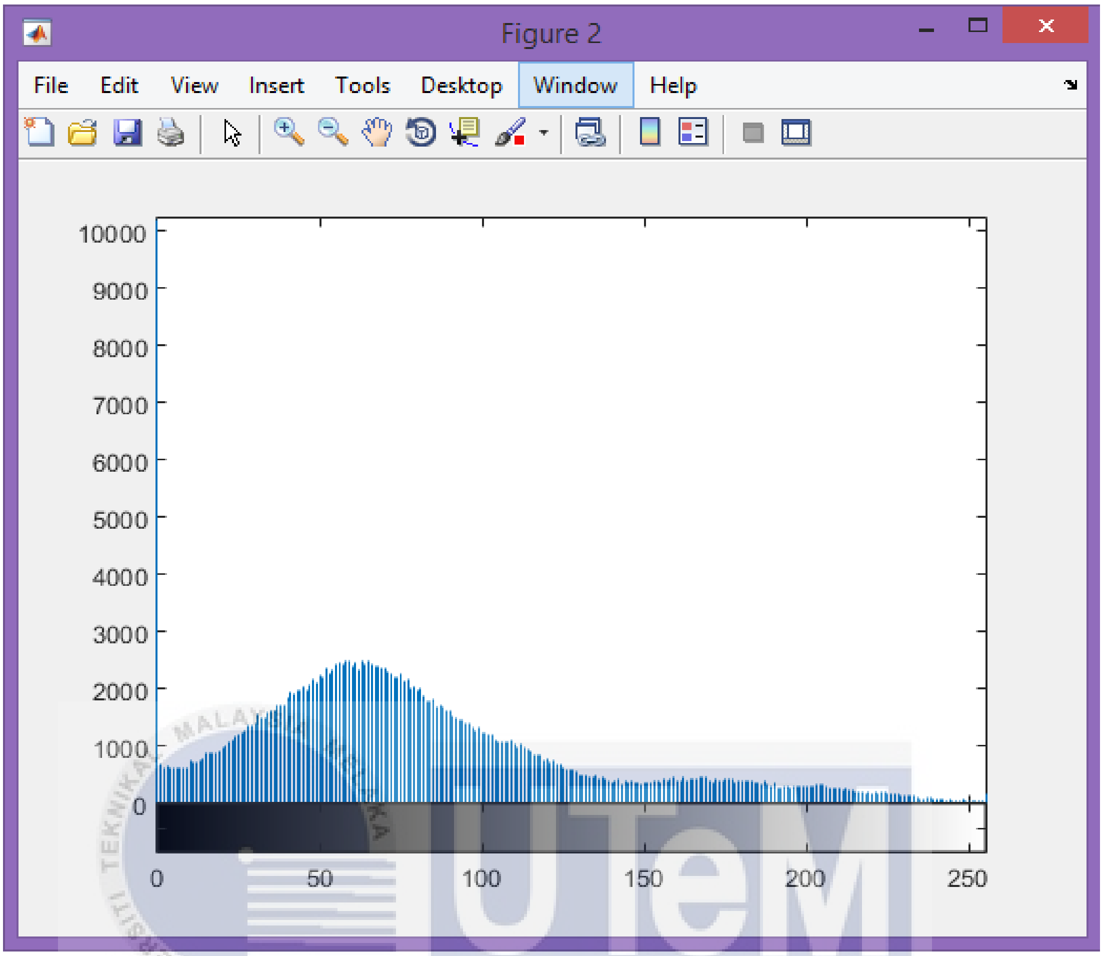

Figure 4.15: Histogram of image subtraction

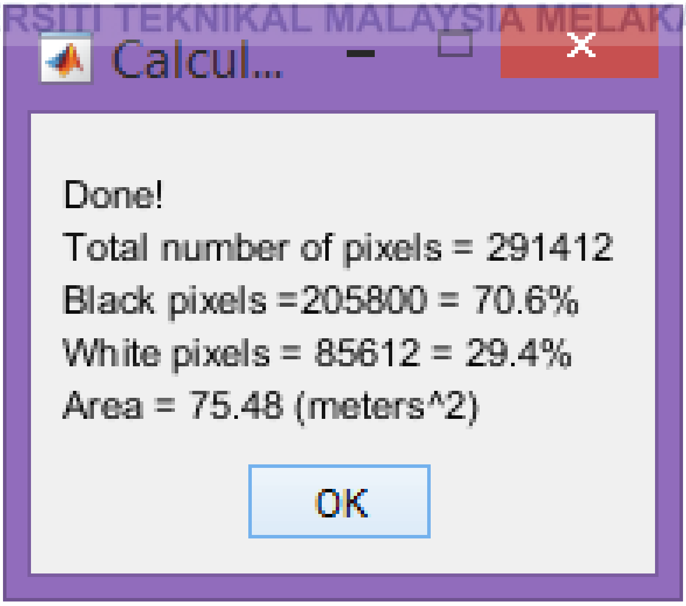

Figure 4.16: Output of calculation for area changed using image subtraction method

The figure above show the final output result for this land cover change detection study. To calculate the total area of changed, first need to calculate the total amount of white pixel from the images as the white pixel representing the changes happen in the images. After that, the total area changed is calculated by the formula below:

Area changed = white pixels value × spatial resolution in meter^2

where the spatial resolution = 0.029692 meter

4.2.8 Testing, compare and analysis

To test the accuracy of image subtraction method, the image ratioing method was used to compare between the accuracy of both change detection algorithm. The figure below shows the output of image ratioing method.

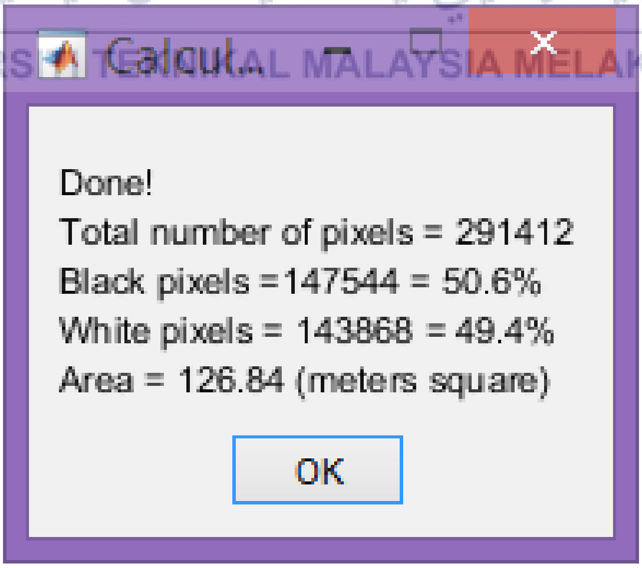

Figure 4.17: Output of calculation for area changed using image ratioing method

After getting the result of both image subtraction method and image ratioing method, the accuracy of both output will be accessed by the error percentage and accuracy percentage. The error percentage and accuracy percentage will be calculated by using the formula below:

$$\textbf{Error percentage} = \frac{|actual\ area - predition\ area|}{actual\ area} \times \mathbf{100}\%$$

$$\textbf{Accuracy percentage} = (\mathbf{100} - \textbf{error percentage})\%$$

Table 4.1: Accuracy Assessment of Output with two methods

Method	Total area of changed in meter square	Total changed pixel(actual pixel)	Total area of changed in meter square (actual pixel)	Error percentage (%)	Accuracy percentage (%)
Image Subtraction	75.48	99729	87.92	14.14	85.85
Image Ratioing	126.84	99729	87.92	44.27	55.73

From the table above, obviously the image subtraction method provide more accurate output compare to image ratioing method. The image subtraction method has the 85.85% of accuracy percentage while the image ratioing method just have the accuracy percentage around 55.73%. Furthermore, between the two same algebra-based change detection algorithm, image subtraction method can provide more accurate result either in quantitatively or qualitatively.

4.3 Conclusion

In conclusion, the outputs obtained have successfully shown the changes that occurred between two UAV images from different dates. The results shows that the image subtraction technique was able to determine land cover change quantitatively and qualitatively, with relatively high accuracy. The further analysis for testing, compare and analysis for accuracy will be explain in the Chapter 5.

CHAPTER V

ACCURACY ASSESSMENT / TESTING

5.1 Introduction

In this chapter, accuracy assessment of the change detection will be discussed to verify the land cover changes that occurred. Based on the results in chapter 4, the image subtraction method gives a higher accuracy compared to the image ratioing method.

5.2 Samples for testing Experiment

Two sets of data were used for the testing experiment. The two set of samples data represented the different situation of changes that happened on the land cover. These samples have different aspect such as no changes and have a significant changes for that area.

Figure 5.1: Sample 1 at time 1

Figure 5.2: Sample 1 at time 2

Figure 5.3: Sample 2 at time 1

Figure 5.4: Sample 2 at time 1

5.3 Comparison Analysis

Before the comparison analysis, the two samples data was implemented with the algorithm written in Matlab software for the testing purpose..

The figures below show the output of the above two samples data using the image subtraction.

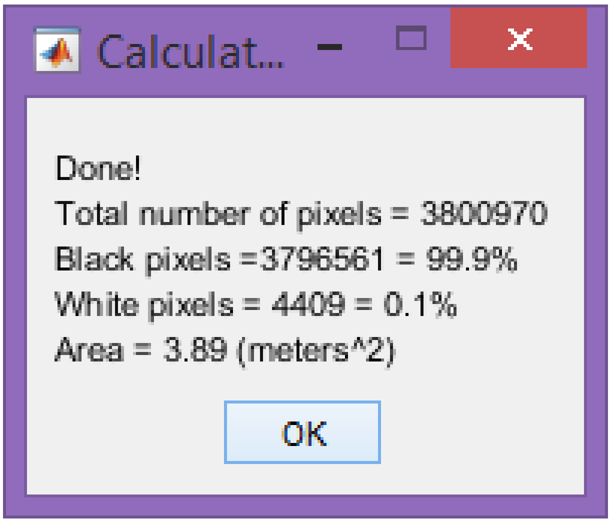

Figure 5.5: Output of sample 1 with image subtraction method

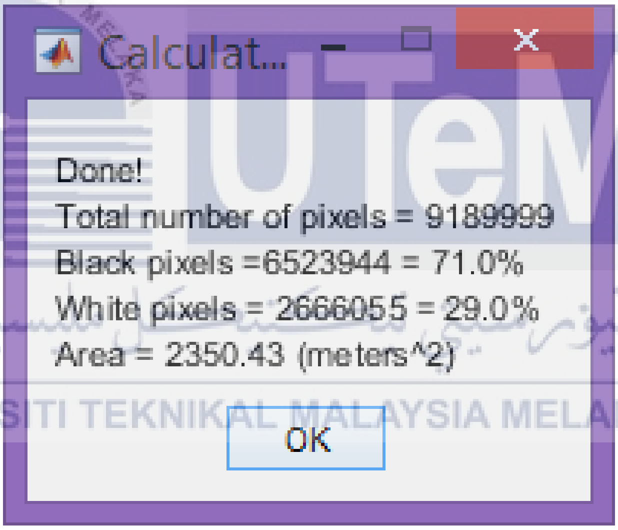

Figure 5.6: Output of sample 2 with image subtraction method

From the outputs above, an accuracy table can be drawn to show the result and error percentage and accuracy percentage.

Table 5.1: Accuracy Assessment of 2 samples of data

Method / Data	Image Subtraction			
	Total area of changed in meter square	Total area of changed in meter square (actual pixel)	Error percentage (%)	Accuracy percentage (%)
Sample 1	3.89	4.54	14.32	85.68
Sample 2	2350.43	2602.66	9.69	90.31

5.4 Conclusion

In conclusion, this chapter has explained in detail the accuracy assessment of the change detection method. Two different samples of data for test the accuracy of image subtraction algorithm were used. It is proven that the accuracy using image subtraction method is high and suitable for the land cover change detection.

CHAPTER VI

CONCLUSION

6.1 Introduction

In this final chapter of the report, the strength and weaknesses of this project will be explained and suggestion of improvement for future work also will be discussed.

6.2 Strength

Table 6.1 Accuracy Assessment of Output with two methods

Method	Total area of changed in meter square	Total changed pixel(actual pixel)	Total area of changed in meter square (actual pixel)	Error percentage (%)	Accuracy percentage (%)
Image	75.48	99729	87.92	14.14	85.85

Subtraction					
Image Ratioing	126.84	99729	87.92	44.27	55.73

Based on the table, image subtraction method gives a better result rather than image ratioing method. The accuracy of image subtraction method is quite high which about 85.85% while image ratioing just have about 55.73%. This indicates that image subtraction method is better than image ratioing method for land cover change detection from UAV platform. Therefore, since the image subtraction method has the highest accuracy. This is consistent with the experiment of testing the image subtraction method by making use different images which has been discussed in Chapter 5. From the experiments, the results of subtraction method show an accuracy of 85% and above with error percentage lower than 15%. The accuracy of this experiment were 85.68% and 90.31%. The result of this study might be influenced by many external factor such as the movement of the UAV, altitude changes of the air or UAV, the noise of UAV image itself etc. Although these external factor may affect the accuracy of the result but it still give very high accuracy for image subtraction method.

Table 6.2: Accuracy Assessment of 2 samples of data

Method / Data	Image Subtraction			
	Total area of changed in meter square	Total area of changed in meter square (actual pixel)	Error percentage (%)	Accuracy percentage (%)
Sample 1	3.89	4.54	14.32	85.68
Sample 2	2350.43	2602.66	9.69	90.31

6.3 Weakness

Although image subtraction method gives high accuracy result on land cover change detection using UAV images, it also have some drawbacks. Image subtraction method cannot provide the complete matrices of change information of change detection. Image subtraction method can show the changes happen but the detailed information of changes such as categories of area changes cannot been known. Besides that, external factor such as the movement of the UAV, altitude changes of the air or UAV between two images can give a very big impact on the accuracy of the result. Also, the image subtraction method work only for two images after image registration.

6.4 Suggestion for Improvement

For future improvement, classification method for change detection can be implemented to get the detailed change information of the UAV image. Moreover, the movement of the UAV, altitude changes of the air or UAV must be controlled during of image acquisition phase to get the same height, location and orientation so that a better performance of the land cover change detection method can be obtained.

6.5 Conclusion

In conclusion, the land cover change detection algorithm has been successfully determined. Image subtraction technique was used to detect changes between two UAV images recorded at different times. The results shows that the image subtraction technique was able to determine land cover change detection quantitatively and qualitatively, with relatively high accuracy. Besides that, the surrounding environment, the controlled variable of image acquisition such as the movement of the UAV, altitude changes of the air or UAV,etc. should be monitored and controlled so it will not causing different effects to the imagery that could affect the result of the study.

REFERENCES

A Comparative Study of Image Change Detection Algorithms in MATLAB. (2016). *Sciencedirect.com*. Retrieved 26 May 2016, from http://www.sciencedirect.com/science/article/pii/S2214241X15001789

Afify, H. (2011). Evaluation of change detection techniques for monitoring land-cover changes: A case study in new Burg El-Arab area. *Alexandria Engineering Journal*, *50*(2), 187-195. http://dx.doi.org/10.1016/j.aej.2011.06.001

Al-Doski, J., Mansor, S. B., & Shafri, H. Z. (2013). Support vector machine classification to detect land cover changes in Halabja City, Iraq. *2013 IEEE Business Engineering and Industrial Applications Colloquium (BEIAC)*.

Best Quadcopters | Quadcopter Reviews | RC Quadcopters for Sale | Drones. (2016). Retrieved from https://droneflyers.wordpress.com/aerial-photography/walkera-gps-qr-x800/

Canon PowerShot S100 - PowerShot and IXUS digital compact cameras - Canon UK. (2016). *Canon.co.uk*. Retrieved 30 April 2016, from http://www.canon.co.uk/for_home/product_finder/cameras/digital_camera/powershot/powershot_s100/#p-specification10

Canon PowerShot SX260 HS Review. (2012). dpreview.com. Retrieved 30 April 2016, from http://www.dpreview.com/reviews/canon-powershot-sx260-hs/2

Chen, J., Gong, P., He, C., Pu, R., & Shi, P. (2003). Land-Use/Land-Cover Change Detection Using Improved Change-Vector Analysis. *Photogrammetric Engineering & Remote Sensing*, *69*(4), 369-379. http://dx.doi.org/10.14358/pers.69.4.369

Jose Furtado, J., Zhihua, C., & Xiaobo, L. (2010). DIGITAL IMAGE PROCESSING: SUPERVISED CLASSIFICATION USING GENETIC ALGORITHM IN MATLAB TOOLBOX, 53-61. Retrieved from http://www.sciencepub.net/report/report0206/09_3172report0206_53_61.pdf

Eling, C., Wieland, M., Hess, C., Klingbeil, L., & Kuhlmann, H. (2015). DEVELOPMENT AND EVALUATION OF A UAV BASED MAPPING SYSTEM FOR REMOTE SENSING AND SURVEYING APPLICATIONS. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, *XL-1/W4*, 233-239. http://dx.doi.org/10.5194/isprsarchives-xl-1-w4-233-2015

Feng, Q., Liu, J., & Gong, J. (2015). UAV Remote Sensing for Urban Vegetation Mapping Using Random Forest and Texture Analysis. *Remote Sensing*, *7*(1), 1074-1094. http://dx.doi.org/10.3390/rs70101074

Fisher, R. *Change Detection in Color Images*. Retrieved 26 May 2016, from http://homepages.inf.ed.ac.uk/rbf/PAPERS/iccv99.pdf

Hussain, M., Chen, D., Cheng, A., Wei, H., & Stanley, D. (2013). Change detection from remotely sensed images: From pixel-based to object-based approaches. *ISPRS Journal Of Photogrammetry And Remote Sensing*, *80*, 91-106. http://dx.doi.org/10.1016/j.isprsjprs.2013.03.006

Kumar, M. DIGITAL IMAGE PROCESSING. *Satellite Remote Sensing And GIS Applications In Agricultural Meteorology*, 81-102. Retrieved from http://www.wamis.org/agm/pubs/agm8/Paper-5.pdf

Kressler, F., & Steinnocher, K. (1996). *Change Detection in Urban Areas Using Satellite Images and Spectral Mixture Analysis*. *International Society for Photogrammetry and Remote Sensing*. Retrieved 25 March 2016, from http://www.isprs.org/proceedings/xxxi/congress/part7/379_XXXI-part7.pdf. Cited in Jensen,J.R., 1986, Digital Image Processing. Prentice-Hall, New Jersey.

Mallupattu, P., & Sreenivasula Reddy, J. (2013). Analysis of Land Use/Land Cover Changes Using Remote Sensing Data and GIS at an Urban Area, Tirupati, India. *The Scientific World Journal*, *2013*, 1-6. http://dx.doi.org/10.1155/2013/268623

Mission Planner Overview — Mission Planner documentation. (2016). *Copter.ardupilot.org*. Retrieved 30 April 2016, from http://copter.ardupilot.org/planner/docs/mission-planner-overview.html

Pacifici, F. (2007). Change Detection Algorithms: State of the Art. Retrieved from http://www.disp.uniroma2.it/earth_observation/pdf/CD-Algorithms.pdf

Singh, A., 1989, Digital change detection techniques using remotely-sensed data. International Journal of Remote Sensing, 10, pp. 898-1003.

S100, C. (2016). *Canon PowerShot S100: Digital Photography Review*. *Dpreview.com*. Retrieved 30 April 2016, from http://www.dpreview.com/products/canon/compacts/canon_s100/specifications

Torres-Sánchez, J., López-Granados, F., De Castro, A., & Peña-Barragán, J. (2013). Configuration and Specifications of an Unmanned Aerial Vehicle (UAV) for Early Site Specific Weed Management. *Plos ONE*, *8*(3), e58210.

http://dx.doi.org/10.1371/journal.pone.0058210, from
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0058210#s2

Xu, L., Zhang, S., He, Z., & Guo, Y. (2009). The comparative study of three methods of remote sensing image change detection. 2009 17th International Conference on Geoinformatics

ZURICH, E. (2009). *UAV Photogrammetry*. Retrieved 30 April 2016, from
http://www.igp-data.ethz.ch/berichte/blaue_Berichte_PDF/105.pdf

APPENDICES

1.1 Grant chart

ACTIVITIES / WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Proposal PSM : Submission																
Proposal Correction/Improvement																
Chapter 1:Introduction																
Preparation of Chapter 1 & Chapter 2																
Chapter 2: Literature review																
Preparation of Chapter 2 & Chapter 3																
Project Demo & Chapter 3 Chapter 4																
MID SEMESTER BREAK																
Demo and Chapter 4																
Progress Report 2 presentation																
Demo																
Final year project 1 Demo																
Presentation																
Final Presentation Final Year Project 1																

1.2 Coding

```
function varargout = psm2(varargin)
% PSM2 MATLAB code for psm2.fig
%       PSM2, by itself, creates a new PSM2 or raises the existing
%       singleton*.
%
%       H = PSM2 returns the handle to a new PSM2 or the handle to
%       the existing singleton*.
%
%       PSM2('CALLBACK',hObject,eventData,handles,...) calls the local
%       function named CALLBACK in PSM2.M with the given input arguments.
%
%       PSM2('Property','Value',...) creates a new PSM2 or raises the
%       existing singleton*.  Starting from the left, property value pairs are
%       applied to the GUI before psm2_OpeningFcn gets called.  An
%       unrecognized property name or invalid value makes property application
%       stop.  All inputs are passed to psm2_OpeningFcn via varargin.
%
%       *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%       instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help psm2

% Last Modified by GUIDE v2.5 11-Jul-2016 17:55:48

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @psm2_OpeningFcn, ...
                   'gui_OutputFcn',  @psm2_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
```

```
end
% End initialization code - DO NOT EDIT

% --- Executes just before psm2 is made visible.
function psm2_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to psm2 (see VARARGIN)
set(handles.axes4,'XtickLabel',[],'YtickLabel',[]);
set(handles.axes4,'xcolor','W');
set(handles.axes4,'ycolor','W');

set(handles.axes3,'XtickLabel',[],'YtickLabel',[]);
set(handles.axes3,'xcolor','W');
set(handles.axes3,'ycolor','W');

% Choose default command line output for psm2
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes psm2 wait for user response (see UIRESUME)
% uiwait(handles.figure1);

% --- Outputs from this function are returned to the command line.
function varargout = psm2_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

% --- Executes on button press in pushbutton11.
function pushbutton11_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton11 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global im im3 imageThreshold1
a= im;
b= im3;
a=a(:,:,1);
```

```
b=b(:,:,1);
d =imdivide(a,b);
imageThreshold1 = ratioing(a,b,d);

% --- Executes on button press in pushbutton12.
function pushbutton12_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton12 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global imageThreshold1

choice=questdlg('Do you want computed area change?','Computed area','Yes','No','No');
%handle response
switch choice
    case 'Yes'
[rows1,columns1,numberOfColorBands1] = size(imageThreshold1);
numberOfBlackPixels1 = sum(sum(imageThreshold1 == 0));
numberOfWhitePixels1 = sum(sum(imageThreshold1 == 255 ));
change1=numberOfWhitePixels1;
areachanged1= change1 * (0.029692^2);
totalNumberOfPixels1 = rows1 * columns1;
percentBlackPixels1 = 100.0 * numberOfBlackPixels1 /totalNumberOfPixels1;
percentWhitePixels1 = 100.0 * numberOfWhitePixels1 /totalNumberOfPixels1;
message = sprintf('Done!\nTotal number of pixels = %d\nBlack pixels =%d = %.1f%%\nWhite pixels = %d = %.1f%%\nArea = %.2f (meters square) ', ...
totalNumberOfPixels1, numberOfBlackPixels1, percentBlackPixels1, ...
numberOfWhitePixels1, percentWhitePixels1,areachanged1);
 msgbox((message),'Calculation ');
    case'No'

end

% --- Executes on button press in pushbutton7.
function pushbutton7_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global im im2
[path,user_cance]=imgetfile();
if user_cance
msgbox(sprinf('ERROR'),'Error','Error');
return
end
im=imread(path);
% im=im2double(im);%convert to double
```

```
im2=im; %for backup process
axes(handles.axes4);
imshow(im);

% --- Executes on button press in pushbutton8.
function pushbutton8_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton8 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global im3 im4
[path,user_cance]=imgetfile();
if user_cance
msgbox(sprintf('Error'),'Error','Error');
return
end
im3=imread(path);
% im3=im2double(im3);%convert to double
im4=im3; %for backup process
axes(handles.axes3);
imshow(im3);

% --- Executes on button press in pushbutton9.
function pushbutton9_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
cla(handles.axes4,'reset');
cla(handles.axes3,'reset');
set(handles.axes4,'XtickLabel',[],'YtickLabel',[]);
set(handles.axes4,'xcolor','W');
set(handles.axes4,'ycolor','W');

set(handles.axes3,'XtickLabel',[],'YtickLabel',[]);
set(handles.axes3,'xcolor','W');
set(handles.axes3,'ycolor','W');

% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global im im3 imageThreshold

a= im;
b= im3;
a=a(:,:,1);
b=b(:,:,1);
d = abs(b-a);
```

```
imageThreshold = subtraction(a,b,d);

% --- Executes on button press in pushbutton6.
function pushbutton6_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton6 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
global imageThreshold

choice=questdlg('Do you want computed area change?','Computed area','Yes','No','No');
%handle response
switch choice
    case 'Yes'
[rows,columns,numberOfColorBands] = size(imageThreshold);
numberOfBlackPixels = sum(sum(imageThreshold == 0));
numberOfWhitePixels = sum(sum(imageThreshold));
change=numberOfWhitePixels;
areachanged= change * (0.029692^2);
totalNumberOfPixels = rows * columns;
percentBlackPixels = 100.0 * numberOfBlackPixels /totalNumberOfPixels;
percentWhitePixels = 100.0 * numberOfWhitePixels /totalNumberOfPixels;
message = sprintf('Done!\nTotal number of pixels = %d\nBlack pixels =%d = %.1f%%\nWhite pixels = %d = %.1f%%\nArea = %.2f (meters square)% ', ...
totalNumberOfPixels, numberOfBlackPixels, percentBlackPixels, ...
numberOfWhitePixels, percentWhitePixels,areachanged);
 msgbox((message),'Calculation ');
    case'No'

end
```

```
function [threshold] = subtraction(a,b,d)

figure(1),subplot(1,3,1),imshow(a),title('Time 1')
subplot(1,3,2),imshow(b),title('Time 2')
subplot(1,3,3),imshow(d),title('After Image Subtraction')

% allocate space for thresholded image
G=imhist(d);
figure(2),imhist(d);
%converted the 2d matrix to 1d matrix
H=reshape(G,[],1);
Ind=0:255;

Index=reshape(Ind,[],1);
```

```
%After calculating the weights and the variance,
%the final computation is stored in the array 'result'.
result=zeros(size([1 256]));
for i=0:255

    [wbk,varbk]=calculate(1,i);
    [wfg,varfg]=calculate(i+1,255);
    result(i+1)=(wbk*varbk)+(wfg*varfg);

end

%Find the minimum value in the array.
[threshold_value,val]=min(result);

tval=(val-1)/256;
valin255=tval*255;


%convert the image to binary with the calculated threshold value
bin_im=im2bw(d,tval);
threshold = bin_im;
figure(3),imshow(bin_im);
str=sprintf('Otsu''s Thresholding value=%.4f',valin255);
title(str)

threshold = bin_im;


    function [weight,var]=calculate(m,n)

        %Weight Calculation

        weight=sum(H(m:n))/sum(H);

        %Mean Calculation

        value=H(m:n).*Index(m:n);
        total=sum(value);
        mean=total/sum(H(m:n));
        if(isnan(mean)==1)
            mean=0;
        end
        %Variance calculation.

        value2=(Index(m:n)-mean).^2;
        numer=sum(value2.*H(m:n));
        var=numer/sum(H(m:n));
        if(isnan(var)==1)
            var=0;
        end

    end
end
```

```
function [threshold] = ratioing(a,b,d)


% figure(1),subplot(1,2,1),imshow(d), subplot(1,2,2),imhist(d)
[i,j]=size(d);

% allocate space for thresholded image
image_thresholded = zeros(size(d));

for ii=1:i
    for jj=1:j
        % get pixel value
        pixel=d(ii,jj);
          % check pixel value and assign new value
          if pixel==1
              new_pixel=0;
          elseif pixel~=1
              new_pixel=255;
          %else
              %new_pixel = pixel;
          end
          %save new pixel value in thresholded image
          image_thresholded(ii,jj)=new_pixel;
      end
end

figure(1)
subplot(1,3,1)
imshow(a)
title('Time 1')
subplot(1,3,2)
imshow(b)
title('Time 2')
subplot(1,3,3)
imshow(d)
title('After Image Ratioing')
threshold = image_thresholded;
figure(2),imhist(d)
figure(3),imshow(image_thresholded)
```