

# **IMAGE ANALYSIS ON REMOTE SENSING IMAGES**

**AZRATUL HUSNA AZUDDIN**

**Universiti Sains Malaysia**

**2006**

## ABSTRACT

Humans easily identify roads in remote sensing images, but this task is difficult to automate using computers. In order to identify road segments from satellite images, human beings (experts) seem to first search for a set of linear and curvilinear features and then apply knowledge or use experience to decide (or guess) whether these linear and curvilinear features are roads or not. From the image, the roads can be detected in a single line to perform as a map or digital map nowadays. The selected image that I used here is a satellite image of an area which had a network of roads. The satellite image is analyzed from one step to another step in different process using MATLAB software. The important processes must be done to the satellite image before the single road lines can be detected. A detection theory is used which can be done by computer to overcome drawbacks of current theories and detect major roads in an image with high speed and high precision. The technique is combining image segmentation and image enhancement process. In this project, the enhancement of the satellite image is the important process in road detection process. Firstly, an image in any file formats is load/save into the workspace folder in MATLAB. The input image is converted into grayscale form. Before continue the next step, first the grayscale image is enhanced for better intensity. In this process, many function of enhancement are used to get the better image for the output. The function that used for the enhancement processes are `imadjust`, `histeq`, and `adapthisteq`. Comparing all the result using those functions, the best-enhanced image is selected to the next step. The process of image segmentation that involve in this project is edge detection. The edge detection is done using Laplacian of Gaussian detector. The segmentation process required an intensity image for all the process involved.

## ABSTRAK

Manusia biasanya amat mudah mengenalpasti jalan raya di dalam imej penderiaan jauh, tetapi tugas ini amat sukar dilakukan menggunakan komputer. Untuk mengenalpasti bahagian-bahagian jalan raya di dalam sesebuah imej satelit, manusia (pakar-pakar tertentu) telah menyelidik sekumpulan ciri-ciri atau sifat lurus dan garis melengkung dan menggunakan pengetahuan atau pengalaman yang ada untuk membuat keputusan (atau tekaan) sama ada sifat lurus dan garis melengkung itu adalah jalan raya atau tidak. Daripada imej tersebut, jalan raya dapat dikesan dalam bentuk garis perseorangan untuk ditunjukkan sebagai peta atau peta digital pada masa sekarang. Imej tersebut dianalisis daripada satu langkah ke satu langkah yang lain dalam proses yang berbeza menggunakan perisian MATLAB. Proses-proses yang penting mesti dilakukan kepada imej satelit tersebut sebelum garis jalan raya dapat dikesan. Imej yang digunakan di sini adalah imej satelit bagi satu kawasan yang mempunyai rangkaian jalan raya. Satu teknik telah digunakan di mana ia dapat dilaksanakan oleh komputer untuk mengatasi kelemahan teori-teori sebelum ini dan dapat mengesan jalan raya di dalam sesebuah imej dalam masa yang singkat dan saksama. Pendekatan yang digunakan ini adalah dengan menggabungkan proses peruasan imej dan proses peningkatan imej. Pertama, imej di dalam apa jua format dimuat atau disimpan di dalam fail ruang kerja di dalam MATLAB. Kemudian imej masukan tersebut ditukar kepada bentuk 'grayscale'. Sebelum memasuki ke langkah seterusnya, imej 'grayscale' tersebut ditingkatkan untuk mendapatkan keamatan yang lebih baik. Di dalam proses ini, pelbagai fungsi peningkatan digunakan untuk mendapatkan imej yang lebih baik pada keluarannya. Proses peruasan imej yang terlibat dalam project ini adalah pengesanan tepi. Peruasan ini memerlukan imej keamatan untuk semua proses yang terlibat.

## ACKNOWLEDGEMENTS

Alhamdulillah, grateful to the God Al Mighty because the permission and kindness for me to complete my final year project. Because of that, I can settle my report for the final year project in my final semester.

Firstly, I want to send my appreciation and a million thanks to my supervisor, Dr. Khoo Bee Ee for the guidance and advices that she gave along the period of doing this final year report. In particular I wish to extend my appreciation to my co-supervisor, Dr. Mohd Sanusi S.Ahamad for his time to give some information about this project to me.

Beside that, I wish to thank to Media & Automation Services Unit, Engineering Library, Universiti Sains Malaysia for providing the satellite images data.

I take this opportunity to thanks to all my friends, for their help and encouragement to me to my final year project. Not to forget my other two friends, Husna Baharom and Ahmad Izuan Ismail who had lending me their books as a references along the period of doing my final year project and their knowledge about image processing.

Finally, to my parents and my sister who had support me and encourage me to do this report and their prayer for me along the period, thanks a lot to them.

Truly, all the loyal service and sacrifice from you all only Allah S.W.T can repay back. All the goodness is come from the God and the deterioration come from my own weakness.

Thank you.

# CONTENTS

	Pages
<b>ABSTRACT</b>	ii
<b>ABSTRAK</b>	iii
<b>ACKNOLEDGEMENT</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF FIGURES</b>	vii
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 Image Analysis on Remote Sensing Images.....	1
1.2 Objective and Scope Study.....	10
1.3 Report Guidance.....	11
<b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 Image Analysis.....	13
2.2 Road Extraction Based on Current Theories.....	14
<b>CHAPTER 3 FUNDAMENTAL OF MATLAB</b>	
3.1 Background on MATLAB.....	16
3.2 MATLAB Working Environment.....	17
3.3 MATLAB Toolbox for Image Processing.....	19
<b>CHAPTER 4 ROAD EXTRACTION IN PROPOSED APPROACH</b>	
4.1 Introduction.....	21
4.2 Methodology.....	24
<b>CHAPTER 5 RESULTS</b>	
5.1 Introduction.....	36
5.2 Data Requirement.....	37
5.3 Results for Road Extraction from Satellite Images.....	38

**CHAPTER 6 CONCLUSION.....50**

**APPENDIX A: SOURCE CODES**

**APPENDIX B: FUNCTION SUMMARY**

## LIST OF FIGURES

<b>Figure 1.1:</b> An image coordinate system	page 1
<b>Figure 1.2:</b> The Flows of Energy and Information in Remote Sensing	page 2
<b>Figure 3.1:</b> the MATLAB desktop and its principal components	page 17
<b>Figure 4.1:</b> Roads in satellite images	page 22
<b>Figure 4.2:</b> Flow chart of road extraction	page 24
<b>Figure 4.3:</b> An example of input image	page 25
<b>Figure 4.4:</b> The example of histogram for low-contrast image	page 27
<b>Figure 5.1:</b> Satellite images for the input image	page 37
<b>Figure 5.2:</b> Input image in a gray-scale level	page 38
<b>Figure 5.3:</b> Histogram of grayscale image	page 39
<b>Figure 5.4:</b> Result of enhancing the image with default imadjust	page 40
<b>Figure 5.5:</b> Histogram of image from figure 5.4	page 40
<b>Figure 5.6:</b> Result of enhancing the image with default histeq	page 41
<b>Figure 5.7:</b> Histogram of histeq image	page 41
<b>Figure 5.8:</b> Image after histeq with number of intensity level=256	page 42
<b>Figure 5.9:</b> Histogram of image from figure 5.8	page 42
<b>Figure 5.10:</b> Result of enhancing the image with default adapthisteq	page 43
<b>Figure 5.11:</b> Histogram of image from figure 5.10	page 43
<b>Figure 5.12:</b> Result of enhancing the image with parameter NumTiles	page 44
<b>Figure 5.13:</b> After edge function (default edge)	page 46
<b>Figure 5.14:</b> After edge function with threshold:0.01 and sigma:2	page 47
<b>Figure 5.15:</b> The input image and the final output image	page 48
<b>Figure 5.16:</b> Example of road extraction for satellite image 1	page 49
<b>Figure 5.17:</b> Example of road extraction for satellite image 2	page 49

**IMAGE ANALYSIS ON REMOTE SENSING IMAGES;  
ROAD EXTRACTION FROM SATELLITE IMAGES**

**Oleh**

**Azratul Husna Binti Azuddin**

**Disertasi ini dikemukakan kepada  
UNIVERSITI SAINS MALAYSIA**

**Sebagai memenuhi sebahagian daripada syarat keperluan  
untuk ijazah dengan kepujian**

**SARJANA MUDA KEJURUTERAAN (KEJURUTERAAN ELEKTRONIK)**

**Pusat Pengajian Kejuruteraan  
Elektrik dan Elektronik  
Universiti Sains Malaysia**

**Mei 2006**

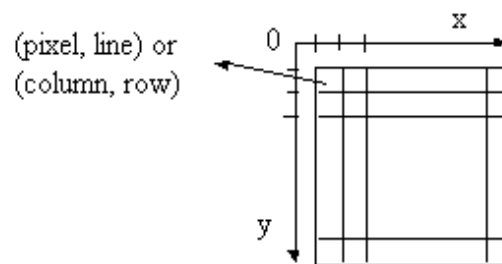


## CHAPTER 1: INTRODUCTION

### 1.1 Image Analysis on Remote Sensing Images

#### Basic Definitions

Based on book written by Geladi and Grahn (1996), an image is a rendering of a real object or situation-a scene-on some preserving medium while Rafael (2002) states that image may be defined as a two-dimensional function,  $f(x, y)$ , where  $x$  and  $y$  are spatial (plane) coordinates, and the amplitude of  $f$  at any pair of coordinates  $(x, y)$  is called intensity or gray level of the image at that point.



**Figure 1.1:** An image coordinate system

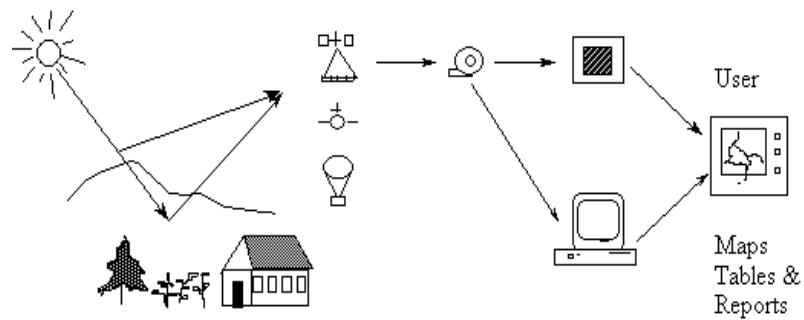
Image pixel values represent the sampling of the surface radiance. Pixel value is also called image intensity, image brightness or grey level. In a multispectral image, a pixel has more than one grey level. Each grey level corresponds to a spectral band. These grey levels can be treated as grey-level vectors.

Image analysis is the extraction of useful information from images; mainly from digital images by means of digital image processing techniques. Image analysis tasks can be as simple as reading bar coded tags or as sophisticated as identifying a person by its face. That statement is the definition of image analysis which state in [en.wikipedia.org](http://en.wikipedia.org).

Remote sensing is a method for gathering data on a large or landscape scale which do not involve on-the-ground measurement, especially satellite photographs and aerial photographs; often used in conjunction with Geographic Information Systems.

The concept of remote sensing:

Remote sensing is a technology used for obtaining information about a target through the analysis of data acquired from the target at a distance. It is composed of three parts, the targets - objects or phenomena in an area; the data acquisition - through certain instruments; and the data analysis - again by some devices. This definition is so broad that the vision system of human eyes, sonar sounding of the sea floor, ultrasound and x-rays used in medical sciences, laser probing of atmospheric particles, are all included. The target can be as big as the earth, the moon and other planets, or as small as biological cells that can only be seen through microscopes. A diagrammatic illustration of the remote sensing process is shown in Figure 1.1.



**Figure 1.2:** The Flows of Energy and Information in Remote Sensing

An essential component in geometrics, natural resource and environmental studies is the measurement and mapping of the earth surface - land and water bodies.

Remote sensing data acquisition can be conducted on such platforms as aircraft, satellites, balloons, rockets, space shuttles, etc. Inside or on-board these platforms, we use sensors to collect data. Sensors include aerial photographic cameras and non-photographic instruments, such as radiometers, electro-optical scanners, radar systems, etc. Electromagnetic energy is reflected, transmitted or emitted by the target and recorded by the sensor. Because energy travels through the medium of the earth's atmosphere, it is modified such that the signal between the target and the sensor will differ.

## Application of Remote Sensing

Earth application remote sensing involves the use of imaging sensors and other instrument mounted on aircraft; spacecraft, undersea vehicle and platforms, or other systems designed to measure or monitor the earth's characteristics. Many spectral instruments now return data that can be processed using image manipulation technology. The major subdivision of remote sensing that involves the use of imaging sensors stated by Green (1983) in his book includes the following:

**Mineral Exploration.** Normally involves the use of multispectral imagery for analysis of surface composition that may indicate mineral deposition and for analysis of surface structure. Image processing techniques include image enhancement, multispectral classification, and correlation of image data with other geographically referenced data bases.

**Determination of Surface Composition.** Surface composition can be estimated from knowledge of the reflectance properties of various types of materials. Multispectral imaging provides one mechanism for determining surface composition. The most frequently utilized technique includes multispectral image enhancement and classification, and image rationing.

**Land-Use Analysis.** Remotely sensed imagery can be used to determine various categories of land utilization. The image processing techniques include cartographic projection, correlation of image data with nonimaging geographically referenced data bases, image differencing, and multispectral image classification and analysis.

**Agricultural and Forestry Applications.** The use of multispectral imagery and images acquired at different times of the year can provide an indication of crop types in agricultural areas and of forest cover types of forested regions. Remotely sensed imagery can provide a basis for monitoring and for detection of significant changes as well as for developing inventories of various crop types or forest cover.

**Ocean Monitoring.** Multispectral imagery can be used to monitor the quality of ocean water, especially near coastlines. High-resolution imaging devices can be used to determine wave patterns and ice pack structure. Synthetic-aperture radar systems are ideal for these applications, and SEASAT satellite demonstrated the viability of this technique for monitoring ocean dynamics. The major image processing techniques used in this type of application include image enhancement, multispectral image manipulation and classification, digital filtering, geometric projection and cartographic registration, and image differencing.

**Weather and Climate Analysis.** Weather patterns and atmospheric properties are continuously monitored from spacecraft-based systems. Synchronous satellite such as the GOES spacecraft monitor a particular area from a constant location above the area in earth orbit, providing periodic imagery and other sensor data that can be used for weather forecasting. Wind speed and cloud motion dynamics can be determined from time-sequential imagery of the same region. The image processing techniques most commonly used include image enhancement, image differencing, and multispectral analysis.

**Undersea Exploration.** Imaging sonar systems and other sensors are increasingly being used to determine the structure and composition of the ocean floor. The image processing techniques include image enhancement, geometric correction, and digital filtering.

## Image Interpretation

Once image data are acquired, we need methods for interpreting and analyzing images. By knowing "what" information we expect to derive from remote sensing, we will examine methods that can be used to obtain the desirable information.

For analyzing images, image interpretation is important to derive useful spatial information from images. Based on website <http://www.cnr.berkeley.edu/~gong/textbook/> it includes as following:

- **Detection** : such as search for hot spots in mechanical and electrical facilities and white spot in x-ray images. This procedure is often used as the first step of image interpretation.
- **Identification** : recognition of certain target. A simple example is to identify vegetation types, soil types, rock types and water bodies. The higher the spatial/spectral resolution of an image, the more detail we can derive from the image.
- **Delineation** : to outline the recognized target for mapping purposes. Identification and delineation combined together are used to map certain subjects. If the whole image is to be processed by these two procedures, we call it image classification.
- **Enumeration** : to count certain phenomena from the image. This is done based on detection and identification. For example, in order to estimate household income of the population, we can count the number of various residential units.
- **Measurement** : to measure the area, the volume, the amount, and the length of certain target from an image. This often involves all the procedures mentioned above. Simple examples include measuring the length of a river and the acreage of a specific land-cover class. More complicated examples include an estimation of timber volume, river discharge, crop productivity, river basin radiation and evapotranspiration.

Elements on which image interpretation are based on:

- Image tone, gray level, or multispectral grey-level vector: Human eyes can differentiate over 1000 colors but only about 16 grey levels. Therefore, color images are preferred in image interpretation. One difficulty involved is use of multispectral image with a dimensionality of over 3. In order to make use of all the information available in each band of image, one has to somehow reduce the image dimensionality.
- Image texture: Spatial variation of image tones. Texture is used as an important clue in image interpretation. It is very easy for human interpreters to include it in their mental process. Most texture patterns appear irregular on an image.
- Pattern: Regular arrangement of ground objects. Examples are residential area on an aerial photograph and mountains in regular arrangement on a satellite imagery.
- Association: A specific object co-occurring with another object. Some examples of association are an outdoor swimming pool associated with a recreation center and a playground associated with a school.
- Shadow: Object shadow is very useful when the phenomena under study have vertical variation. Examples include trees, high buildings, mountains, etc.
- Shape: Agricultural fields and human-built structures have regular shapes. These can be used to identify various targets.
- Size: Relative size of buildings can tell us about the type of land uses while relative sizes of tree crowns can tell us about the approximate age of trees.
- Site: road leaf trees are distributed at lower and warmer valleys while coniferous trees tend to be distributed on a higher elevation, such as tundra. Location is used in image interpretation.

## Image Pre-processing

Pre-processing is the name used for operation on images at the lowest level abstraction-both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwilling distortions or enhances some image feature important for further processing which had been written by Gonzales and Woods (2002) in their book.

For basic types of pre-processing methods exist:

- Brightness transformation
- Geometric transformation
- Local neighborhood pre-processing
- Image restoration

### **Pixel brightness transformation**

There are two classes of pixel brightness transformations:

- Brightness corrections
- Gray-scale transformations

Brightness corrections modify pixel brightness taking into account its original brightness and its position in the image.

Gray-scale transformation change brightness without regard to position in the image.

### **Local neighborhood pre-processing**

Local pre-processing methods use a small neighborhood of pixel in an input image to produce a new brightness value in the output image. For the pre-processing goal, two groups are common: *smoothing* and *edge detection*.

*Smoothing* aims to suppress noise or other small fluctuation in the image. *Edge* is a property attached to an individual pixel and has two component, *magnitude* and *direction*. Most gradient operators can be expressed using *convolution mask*; examples include Roberts, Laplace, Prewitt, Sobel, Robinson, and Kirsch operators.

The edge detector that I can use is the *canny* edge detector for the road detection. The *Canny* edge detector is optimal for step edges by white noise. The optimality criterion is based on requirements of detecting important edges, small localization error, and single-edge response. *Canny* edge detection starts with convolving an image with a symmetric 2D Gaussian and then differentiating in the direction of the gradient; further steps include *non-maximal edge suppression*, *hysteresis thresholding*, and *feature synthesis*. Edges can also detect in multi-spectral images.



## Image Segmentation

Segmentation methods can be divided into three groups: thresholding, edge-based segmentation and region-based segmentation. Each region can be represented by its closed boundary, and each closed boundary describes a region.

### **Thresholding**

Thresholding represents the simplest image segmentation process, and it is computationally inexpensive and fast. A brightness constant called a threshold is used to segment objects and background.

### **Edge-based image segmentation**

Edge-based segmentation relies on edges found in an image by edge detecting operators-these edges mark image locations of discontinuities in gray-level, color, texture, etc. The most common problems of edge-based segmentation, caused by image noise or unsuitable information in an image, are an edge presence in locations where there is no border, and no edge presence where a real border exists.

Edge image thresholding is based on construction of an edge image that is processed by an appropriate threshold. In edge relaxation, edge properties are considered in the context of neighboring edges. If sufficient evidence of the border presence exists, local edge strength increases and vice versa. Using a global relaxation (optimization) process, continuous borders are constructed.

Three types of region borders may be formed: inner, outer and extended. The inner border is always part of a region, but the outer border never is. Therefore, using inner or outer border definition, two adjacent regions never have a common border. Extended borders are defined as single common borders between adjacent regions still being specified by standard pixel co-ordinates.

## **1.2 Objective and Scope Study**

The main objective for this project, image analysis of remote sensing images is based on extraction and detection of road lines in satellite images. The satellite images as an input images will be analyze and process where the process of detecting road lines will become easy and faster than before. The new method for detecting major road network from a satellite images will be produced after doing this project.

Beside that, the objective of this project is to propose a new technique for automatic road detection which can compile insufficient local information to obtain global information. As we know, there will be any other object beside road lines in such satellite images. A special technique must be developed to detect only road lines in the image.

For the major expectations in the use of updating urban/rural maps, such as road network for car navigation system, the project is proposed. In the other hand, the purpose of the project is to overcome the drawback from the previous development method.

### 1.3 Report Guidance

Every chapter in this report contains the criteria and steps beside solution for image analysis for remote sensing images in road detection. In this project, MATLAB is used to implement the image processing and analysis to the input images. The function for each method that used for the solution is stated in this report. The remaining six chapters cover material in the following areas.

**CHAPTER 2: LITERATURE REVIEW.** In this section, the definition of image analysis and remote sensing images is defined in the first part. For the other part, there are a few of remote sensing application that been stated for our knowledge. This chapter also covers the methods that been used before and recently to extract the road from satellite images. The literatures taken from the IEEE explorer are used to gather the information and give the advanced solution. The methods that used before are Hough Transform, Optimal Search, and automatic approach and etc.

**CHAPTER 3: FUNDAMENTAL OF MATLAB.** This chapter deals with the basic of MATLAB Operation beside introduce the background of the MATLAB and MATLAB working environment. In this chapter also give basic information about how to use MATLAB Tools for image processing.

**CHAPTER 4: ROAD EXTRACTION IN PROPOSED APPROACH.** This chapter deals with the methodology that I choose for my proposed approach for road extraction. The strategy of my approach is listed down step by step and the explanations are described one by one.

**CHAPTER 5: RESULTS.** In this section, the results for the proposed approach are point out. The experimental results will be compared from the previous work and the effective of the proposed approach will be known.

**CHAPTER 6: CONCLUSION.** For the conclusion, the result in the previous chapter is confirmed is there any improvement or not using proposed approach.

**REFERENCES.** In this section, a list of all literatures, books, and any source of information is written down as a reference for this project.

**APPENDIX.** In addition to the preceding material, the report contains list of relevant MATLAB function and the source codes for the process that is done using MATLAB software.

## CHAPTER 2:LITERATURE REVIEW

### 2.1 Image Analysis on Remote Sensing

At different levels and scales, many organizations are directly or indirectly using remote sensing image analysis techniques to produce information for a wide range of civil applications, such as urban planning, environmental monitoring, hazard monitoring and prediction, agricultural economics, etc.

In the article written by P.C Smits (1998), it explains about the objectives and feasibility related to image analysis issues in a remote sensing project. The possibilities and impossibilities of automated remote sensing image analysis are discussed deeper in the article. The major components of any remote sensing project are the phenomenon in observation, the sensing systems, the data products, reference data, the interpretation and analysis phase and the generation of the information products that said by Lillesend *et al* (1987).

Image processing and interpretation connect the Earth observation data with software, the definition of the information requirement, and the customer interface. For example there is software where we can used for image analysis especially hyperspectral image analysis. For the further knowledge please refer in Arzuarga *et. al* (2004).

Besides that, there also a few algorithms are applied for image analysis of remote sensing images as said by Jamshidi and Yan Wang (2004), Wei Wu *et. al* (2003).

## 2.2 Road Extraction Based On Current Theories

From the previous part, we have discussed about the meaning of image analysis and remote sensing. For this section I want to point out the theory and many type of model that been studied about the road extraction for pass few years. There are many researches had been done to find the best and easy way to extract or detect line of roads from any satellite images or aerial images.

The automatic detection of roads from satellite images is a very important problem. For two decades, there has been an intensive effort to develop automatic road detection method.

In the detection theory proposed by Rianto and Kondo (2002) such technique were developed and their algorithm for automatic road detection from grayscale SPOT satellite images was proposed. The proposed algorithm made it possible to reduce detection time substantially by using the optimal search method. The method can be applied to images of any size and can detect plural roads including intersecting roads and T-typed roads. The binary image that representing edges of a given image is used to evaluate the possibility for a road to pass on each edge pixel. Many type of filter is used to compile insufficient local information to obtain global information enough to detect a road. Kondo also used Hough transform and the optimal search method to detect the complete road

The detection of the road networks depend on the features of the image such as the resolution, size and type of the image. For detection of main road network in high resolution, panchromatic SPOT satellite images, Duta (2000) states that based on two stages, partial detection and full tracking stages the road can be detected. The method appears to be reliable and robust provided the images are of relatively good quality.

Although the SPOT satellite image has high resolution, but, seeing it locally, it has not enough information to separate roads from background structures. It is necessary to develop some technique, which compile insufficient local information to obtain global information enough to separate roads from other structures.

The Research of Roads Extraction for High Resolution Satellite Image done by Xuan Li *et. al* (2003) stated three-step method for road extraction. The first step is detect the road edge, second step is transform the road edge into vector and the final step is the

transformed road vectors are compared with the existing official road vectors, and then some inaccuracies will be corrected.

Hough transform is another method for the previous work that mostly applied for detecting roads. It is because the Hough transform is a part of line image segmentation for line detection. The Hough is applied by Rianto and Kondo (1998) in their research for detection of roads.

All the theory and method that list above can be applied for road extraction in my project. Using MATLAB program, all the algorithm can be evaluated and implement by specific command for the new method for road detection.

## **CHAPTER 3 : FUNDAMENTAL OF MATLAB FOR IMAGE ANALYSIS**

### **3.1 Background on MATLAB**

As we know, MATLAB refers to both the numerical computing environment and to its core programming language. MATLAB that created by The MathWorks allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. Although it specializes in numerical computing, an optional toolbox interfaces with the Maple symbolic engine, making it a full computer algebra system.

MATLAB integrates computation, visualization, and programming in an easy-to-use environment where problems and solution are expressed in familiar mathematical notation. Typical uses included math and computation, algorithm development, data acquisition, modeling, simulation and prototyping, data analysis, exploration, and visualization, scientific and engineering graphics and application development, including graphical user interface building.

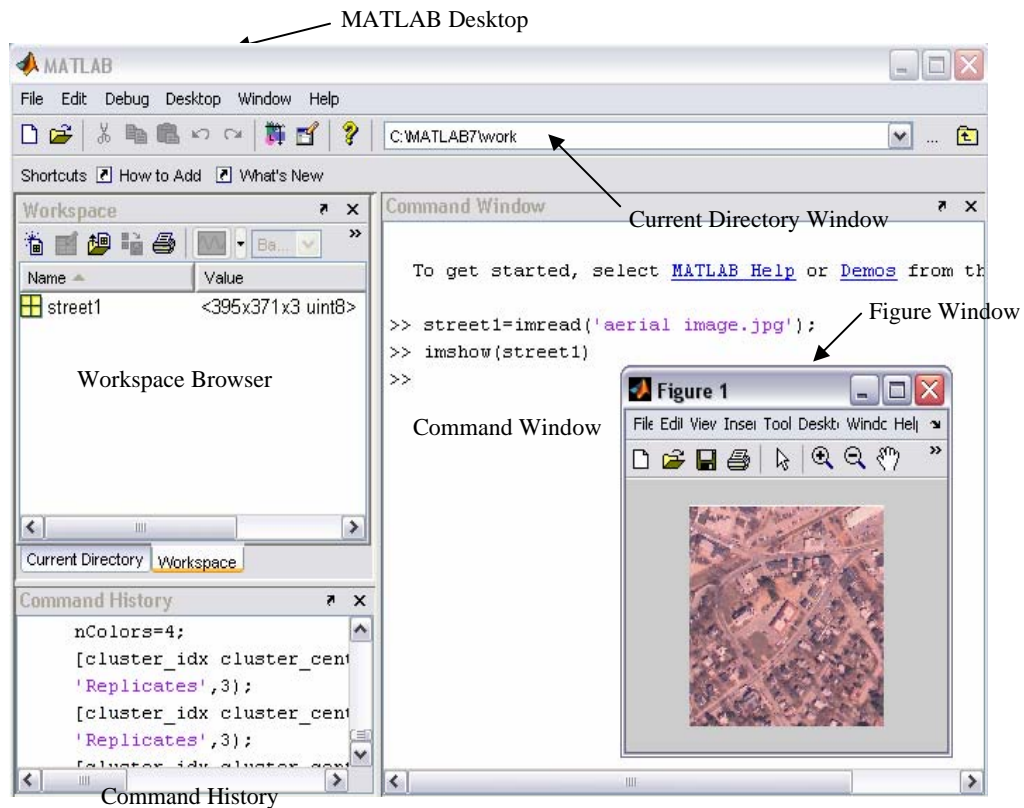
The name MATLAB stands for matrix laboratory. MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (Linear System Package) and EISPACK (Eigen System Package) projects.

MATLAB is the standard computational tool for introductory and advanced courses in mathematics, engineering, and science in university environments. MATLAB is complemented by a family of application specific solution called toolboxes. The Image Processing Toolbox is a collection of MATLAB function that extends the capability of the MATLAB environment for the solution of digital image processing problems.



### 3.2 The MATLAB Working Environment

The MATLAB desktop is the main application window. As Figure 3.1 shows, the desktop contains five sub windows: Command Window, the Workspace Browser, the Current Directory Window, the Command History Window, and one or more Figure Windows, which are shown only when the user displays a graphic.



**Figure 3.1:** The MATLAB desktop and its principal components

The Command Window is where the user types MATLAB commands and expressions at the prompt (>>) and where the outputs of those commands are displayed. MATLAB defines the workspace as the set of variable that the user creates in a work session. The Workspace Browser shows these variables and some information about them. Double-clicking on a variable in the Workspace Browser launches the Array Editor, which can be used to obtain information and in some instances edit certain properties of the variable.

The Current Directory tab above the Workspace tab shows the contents of the current directory, whose path is shown in the Current Directory Window. The MATLAB editor is both a text editor specialized for creating M-files and a graphical MATLAB debugger. The editor can appear in a window by itself, or it can be subwindow in the desktop. M-files are denoted by the extension .m, as in hough.m. The MATLAB editor window has numerous pull-down menus for tasks such as saving, viewing, and debugging files.

The principal way to get help online is to use the MATLAB Help Browser, opened as a separate window either by clicking on the question mark symbol (?) on the desktop toolbar, or by typing helpbrowser at the prompt in the Command Window. The help Browser is a Web browser integrated into the the MATLAB desktop that display HTML (Hypertext Markup Language) documents.

### 3.3 MATLAB Toolbox for Image Processing

The Image Processing Toolbox provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. We can restore noisy or degraded images, enhance images for improved intelligibility, extract features, analyze shapes and textures, and register two images.

The Image Processing Toolbox is a collection of functions that extend the capability of the MATLAB® numeric computing environment. The toolbox supports a wide range of image processing operations, including Spatial image transformations, Morphological operations, Neighborhood and block operations, Linear filtering and filter design, Transforms Image analysis and enhancement, Image registration, Deblurring and Region of interest operations.

Image analysis toolbox describes the toolbox functions that return information about the structure of an image such as edge detection, boundary tracing and quadtree decomposition. The function `edge` is to detect edges, which are those places in an image that correspond to object boundaries. To find edges, this function looks for places in the image where the intensity changes rapidly, using one of these two criteria:

Places where the first derivative of the intensity is larger in magnitude than some threshold

Places where the second derivative of the intensity has a zero crossing

The most powerful edge-detection method that edge provides is the Canny method. The Canny method differs from the other edge-detection methods in that it uses two different thresholds (to detect strong and weak edges), and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges.

Boundary tracing is a toolbox to find the boundaries of objects in a binary image. The `bwtraceboundary` function returns the row and column coordinates of all the pixels on the border of an object in an image. You must specify the location of a border pixel on the object as the starting point for the trace. The `bwboundaries` function returns the row and column coordinates of border pixels of all the objects in an image. For both functions, nonzero pixels belong to an object and pixels with the value 0 (zero) constitute the background.

Quadtree decomposition is an analysis technique that involves subdividing an image into blocks that are more homogeneous than the image itself. This technique reveals information about the structure of the image. It is also useful as the first step in adaptive compression algorithms.

There are many others toolbox in the image processing toolbox that can be used for image analysis especially for road detection such as morphological operation and many more.

## **CHAPTER 4:ROAD EXTRACTION IN PROPOSED APPROACH**

## 4.1 Introduction

Road networks express the basic structure of the earth surface and constantly changes at many rural urban areas. These become basic information to make classification of the use of the earth surface. Many applications such as planning, management, agriculture, environment protection, etc, require recent information of environmental changes.

In addition, digital road network database are considered most important components of Geographical Information System (GIS). Therefore, the availability of a digital map is a very important component for the total market potential of GIS application such as navigation systems. Therefore, the automatic detection of roads from satellite images is a very important problem.

A variety of approaches have been proposed for road extraction, with varying degrees of success. It is common knowledge that there does not exist a single approach outperforming all alternative. Instead, it is often the nature of application at hand that renders certain approaches more suitable for the specific task.

The examples for roads in satellite images which are given in Figure 1.1 indicate some of the problem for road extraction. Although, in the real world, roads are objects with a smooth and firm surface and quite well defined geometrical properties, e.g., maximum curvature or lower and upper bound for their width, their appearance in satellite image can be quite different. Small object like cars markings interfere the homogeneity of the road surface. They can fairly easily be eliminated using the scale-space properties of roads. Larger objects, like buildings or trees, are more difficult to handle. These 3D-objects pose problems due to occlusions and shadows, which cannot be treated using scale-space theory. However, it is clear, that depending on the resolution and on the complexity of the scene, different features and different strategies seem to be useful for road extraction.





**Figure 4.1:** Roads in satellite images

In this project, using image enhancement, the images are processed toward road extraction. The process of the image segmentation and image enhancement are done in gray scale level. For that reason, firstly the input image must be convert into grayscale image before proceed to the next process. The enhancement process also can be done using RGB image or true image.

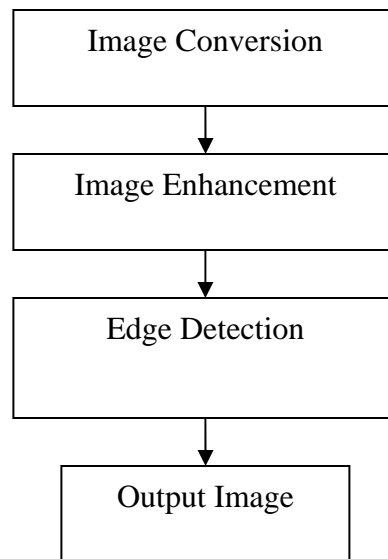
Image enhancement is the process where the intensity of grayscale images is improved to get a better image contrast. To analyze the image contrast whether the grayscale image is in a good image contrast or not, image intensity histogram is the answer for this question. There are many functions that used in the image enhancement technique such as function `imadjust`, `histeq` and `adapthisteq`.

After image enhancement, the next process is apart of image segmentation that I called edge detection. Edge detection process is proposed to extract the contour lines of the object in the input image. For this project, I used Laplacian of Gaussian filter which work by looking for zero crossing for the edge detection. The output of the image was different depends on the input image.

All the steps that proposed are explain deeper in the next section. The flow chart of the step involved is also given in the next section. All the process in the proposed approach is done using MATLAB software.

## **4.2 Methodology**

In this paper, a road extraction method from satellite images is proposed, in which the extracted roads are converted to road lines. The processing steps are shown in Figure 4.1. Each image processing in the flow chart is described below.



**Figure 4.2:** Flow chart of road extraction

a) Image Conversion