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BORANG PENGESAHAN STATUS TESIS

JUDUL **CAR PLATE DETECTION SYSTEM**

SESI PENGAJIAN: **2004/2005**

Saya **GUNASEGARAN KRISHNAN**
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CAR PLATE DETECTION SYSTEM

GUNASEGARAN KRISHNAN

A report submitted in partial fulfillment of the
requirement of the award of the degree of
Bachelor of Computer Technology (Software Engineering)

Faculty of Computer System & Software Engineering
University College of Engineering & Technology Malaysia

MARCH, 2005

I declare that this thesis entitled "*Car Plate Detection System*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree is not concurrently submitted in candidature of any other degree.

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To my beloved father and mother **:** *Thank you for showing me the path of life*

- GUNASEGARAN -

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ABSTRACT

Car Plate Recognition System is an image processing system in which it locates and recognizes a car plate. This technology is still new and only few systems are available in Malaysia. The most crucial part in Car Plate Recognition System is plate location. This is because if the system fails to detect the location of the car plate, then the whole system is a failure because recognition can only be done after successful plate location. Therefore, this research is mainly focused on plate location. In short, this research is entitled *Car Plate Detection System*. This system will focus on 4 major parts of pre-processing phase which are Image Enhancement using median filtering, Thresholding using global threshold value, Feature Extraction using thresholding, and Plate Location using rule-based conditions. This system was developed as a prototype to fulfill the requirement and prove the correctness of the algorithms used. The data or car plates used are strictly typical Malaysian civilian car plate numbers. Image is acquired using digital camera and fed to the system which thresholds the image to convert it into the binary image. Feature extraction is performed to produce the features of the binary image. Finally, the location of the car plate is located using rule based algorithms. The conditions are set as rule and the system detects the car plate if the condition exists. The results are discussed in Chapter 4.

ABSTRAK

Sistem pengecaman nombor plat kereta adalah satu sistem yang menggunakan pemprosesan imej di mana sistem ini mencari lokasi plat kereta mengecam setiap aksara dalam plat tersebut. Teknologi ini masih dalam perkembangan dan masih baru di Malaysia. Pengesanan lokasi plat kereta merupakan bahagian yang paling kritikal kerana sekiranya sistem ini tidak dapat mengesan lokasi, maka fasa pengecaman akan turut gagal. Oleh yang demikian, kajian yang dilakukan adalah lebih tertumpu kepada fasa pengesanan lokasi plat kereta, dan dengan ini prototaip sistem yang akan dibangunkan telah dinamakan *Car Plate Detection System*. Prototaip ini akan memfokus kepada 4 bahagian utama iaitu pemulihan imej menggunkan teknik median, ambangan menggunakan nilai ambangan global, pengeluaran ciri meggunakan teknik ambangan, dan pengesanan lokasi nombor plat menggunakan teknik peraturan. Sistem yang dibangunkan merupakan prototaip sistem sebenar dan dibangunkan bagi menepati kehendak skop kajian. Nombor plat kereta yang digunakan terdiri daripada nombor-nombor plat kereta biasa di Malaysia. Imej plat kereta di ambil menggunakan kamera digital dan dimasukkan ke dalam sistem yang mana sistem akan melakukan ambangan dan menukarkan imej kepada imej binari. Pengeluaran ciri dilakukan bagi menghasilkan ciri-ciri daripada imej binari. Akhir sekali, pengesanan lokasi plat kereta dilakukan menggunakan kirteria-kriteria tertentu. Keputusan dan perbincangan mendalam telah dilakukan di dalam Bab 4.

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LIST OF ABBREVIATIONS

KUKTEM	-	Kolej Universiti Kejuruteraan & Teknologi Malaysia
UTEC	-	University College of Engineering & Technology Malaysia
3D	-	3-Dimension
2D	-	2-Dimension
MSC	-	Malaysian Super Corridor
CARPROS	-	Car Plate Recognition System
AI	-	Artificial Intelligence
CCD	-	Charged Coupled Device
SDLC	-	Software Development Life Cycle
JPEG	-	Joint Photographic Expert Group
BMP	-	Microsoft Bitmap
TIFF	-	Tagged Image File Format
RGB	-	Red, Green, and Blue
JPJ	-	Jabatan Pengangkutan Jalan

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CHAPTER 1

INTRODUCTION

1.1 Introduction

These days a lot of effort is spent on converting the normal human vision into machine vision. A lot of researches have been conducted throughout the world and this field is still expanding from time to time. Due to our human vision's limitation, many works could not be performed since our naked eyes have limited viewing capacity in terms of distance and there are chances for miss interpretation. Therefore, it is learned that machine vision can assist humans to perform specific tasks that could not be performed by human eyes.

Machine vision is actually an application which does not require human input on most cases, although humans are involved in the development of these applications. Once completed, machine vision application does all the necessary computations and produce results as required and with minimal input of information from human. The goal of machine vision is to create a model of the real world images. Since the image that human eyes perceive is 3D, a machine vision system uses 2D representation of the data to extract useful information from the images.

These days, there are many machine vision application exists. Each application extracts information differently according to its functions and purposes. Machine vision application supports many business types ranging from medical, aerospace, geology, manufacturing and also production. For example, the application that is purposed for medical field is used to perform X-Ray, scanning for brain tumor and also for laser operations and automated surgical processes as described by Gonzalez. C.R and Richard. E.W (2002). In geology field, machine vision is used to get and translate satellite images taken from space. The images are used to look for changes in whether, earth's plate movements and also to detect natural disasters.

Although some of these tasks can be performed by normal human eyes, it might take time. Therefore, machine vision has proved its advantages and benefits. More importantly, machine vision is used in security field and to strengthen laws. For example, there are applications installed at traffic lights that can take pictures of cars which run the red lights. Besides that, there are also applications which can provide tight security systems for highly confidential organizations. These include applications like fingerprint recognition entrance, biometrics access, and secured building access using car plate recognition system.

Going in detail on car plate recognition system, it is a complex machine vision application which recognizes the characters on a car plate based on the given conditions and instructions. The car plate recognition system is installed in many places such as toll gates, parking lots and also entrance of highly secured buildings. Even polices are using this application because they can detect speeding vehicles from distance away.

Car plate recognition systems are beneficial because it can automate car park management, improve the security of car park operator and the users as well, eliminate the usage of swipe cards and parking tickets, improve traffic flow during peak hours, improve airport security where limiting drop-off zone parking for five minutes only, detect speeding cars on highways, and detect cars which run over red traffic lights.

Realizing the importance of car plate detection, it is recommended that a research is conducted in this application since in Malaysia, the development of image processing applications are still inadequate. Since Malaysia is venturing into the IT world these days, the government has always been supporting the usage of computerized systems throughout the nation. This can be proved by the famous MSC or known as Malaysian Super Corridor and also by the automation of government departments throughout the nation. Therefore, developing a computerized system in the field of image processing will be quite a new venture.

In this research, the prototype development for the Car Plate Detection System is divided into 4 major phases of image processing. The model was based on the paper entitled *The Automated Inspection of Moving Webs Using Machine Vision* by (Wayne, 1995). The original model was developed for developed to detect defects in material but this model was modified to suit the purpose of Car Plate Detection System. Each phase is inter-related with each of the other phases. The diagrammatic view of the whole processes involved is shown on Figure 1.1.

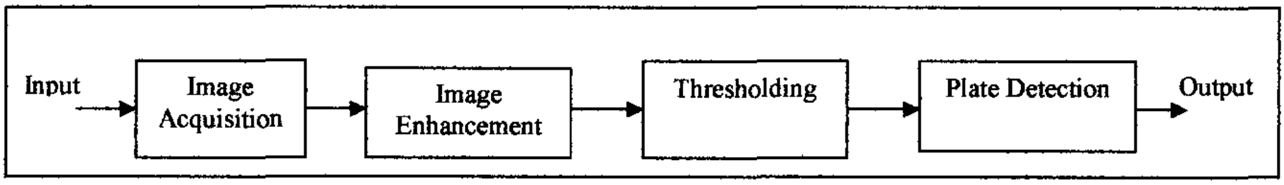


Figure 1.1 Main phases of image processing involved in Car Plate Detection System suggested by Wayne (1995)

The *Car Plate Detection System* will be developed based on the case study method. The environment that will be used to do the case study is University College of Engineering & Technology of Malaysia (UTEC), Gambang, Kuantan. This system is an image processing and recognition system that will capture the vehicle number plate and match the numbers with the vehicle owners. The initial plan for this system is to have a complete database whereby each car's information is fed into the system. The system will then detect the owner's information based on the car plate detected. The complete system with the database will be called as "CARPROS – *Car Plate Recognition System*".

CARPROS is divided into two main modules. The first module is pre-processing whereby the car plate image will be prepared for mathematical operations, located and extracted from the existing image. This whole module is called "*Car Plate Detection System*". Meanwhile, the other module will focus on segmentation of the car plate character and recognition. Combining these two modules, it will give CARPROS.

The technology that will be used to develop the *Car Plate Detection System* is a combination of Image Processing and Artificial Intelligence (AI). The image processing techniques that are applied is basic pre-processing techniques, meanwhile the AI techniques that are applied for plate extraction is rule-based. The use of this AI technique is because there are many conditions for plate extraction.

1.2 Problem Statement

Plate detection is the most important part in an automated car plate recognition system. Failure to detect the location of the plate will eventually fail the entire system. A good and reliable algorithm has to be produced in order for the system to be reliable and fast. The initial image size that is fed to the system is 640 x 480, *gray-scale* image. The color of the image is changed into black and white and proper algorithm has to be applied for exact location and extraction of car plate.

The existing method used in University College of Engineering & Technology Malaysia when detecting vehicles is by using the obsolete sticker system. Each car is given a sticker which contains the car number plate number and this is used as reference when it comes to detect a vehicle in the campus. Staffs uses stickers with blue background meanwhile students use stickers with red background. Failure to display this sticker will be compounded. Whenever there is a visitor, or a car needs to get into the main campus gate, guards need to be at the post to operate the gate.

As a solution, CARPROS should handle the job of handling traffics in and out of the campus. Since CARPROS has a lot benefits, it can be implemented as it can automate the process of controlling the traffic. Besides that, it will be easier to monitor the traffic activity in and out of the campus. In order for CARPROS to be implemented, the "*Car Plate Detection System*" should be developed first. It is very important for this sub-system to be developed properly since this module houses the algorithm for plate detection.

1.3 Objectives

The main objective of the project is to:

a. To develop a prototype of *Car Plate Detection System* focusing on:

   i. Thresholding using global threshold value.
   ii. Filtering using median filtering.
   iii. Feature extraction using thresholding.
   iv. Car plate location detection using rule-based technique.

1.4 Scopes

The scope of the project is limited to the pre-processing phases which include 4 major steps. The main focus of the scope is to develop a prototype of "*Car Plate Detection System*" focusing on pre-processing phases. This prototype will be developed fully using MATLAB Version 6.1 and a little aid from Adobe Photoshop CS. The following are the additional scope for this project:

a. Images are in JPEG format.
b. Only grayscale image is fed into system.

c. Images taken had fixed length between the camera and the number plate (≈ 1.5m).

d. The plate used for testing is only single-line car plates. Refer Figure 1.2.

e. Only clean car plates were used for testing.

f. Only civilian car plates were used.

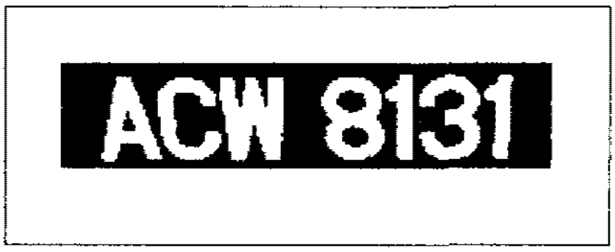


Figure 1.2 Single Line Car Plate

1.5 Thesis Organization

The thesis is divided into 5 essential chapters ranging from Chapter 1 until Chapter 5. The Chapter 1 gives an overview of the research conducted. It also discusses the problem statement, objective and the scope of the research. Meanwhile, Chapter 2 reviews the previous research works conducted by many researches outside. All the relevant researches taken from technical paper, journals, and books are discusses in detail. Chapter 3 reveals the techniques and the algorithms that are used to perform this research. It also discusses the process flow of this research in detail. All the results of the testing is detailed out in Chapter 4. Finally, the Chapter 5 concludes the entire thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, car plate detection is being the baseline for any car plate recognition system. Without this whole detection process, it is almost impossible to complete a car plate recognition system. This actually, implies to all the recognition system like texture recognition, fingerprint recognition and many other recognition system.

The detection system enables us to capture the image and prepare the image for it to be understood by the recognition system. This is essential as it helps us to make the whole recognition process easier because the images will be filtered for noise and will be detailed for easier detection and recognition.

In this thesis, references have been made from various technical papers related to car plate detection and recognition. In short, most of the technical papers emphasizes on few aspects as the most critical portion of the whole image detection process. One of the most important aspects is the algorithm for image processing as it involves various steps such as image filtering, thresholding and thinning. Therefore, all these aspects have been laid out in detail in the following sub-chapters.

In Malaysia, there are 3 types of car plates. The types of the plate depends on the usage of the car; (1) General civilian car possess a black background and white for character, (2) Taxi posses white background and black characters, and finally (3) Diplomat's, International Rubber Association, and PBB's car posses red background with white characters.

The Road and Transport Department of Malaysia have given guidelines and specification for the car plate measurements. The list of important criteria's and specification on a civilian car plate is showed in Table 2.1 meanwhile the detail graphical representation of car plate is shown on Figure 2.1. The figure shows 3 types of civilian car plate measurements that have been released and standardized by the department.

Table 2.1 : Specific plate measurement and criteria of car plate

No.	Specification	Measurement (mm)
1.	Character Height	70
2.	Character Width	40
3.	Distance between characters / numbers	10
4.	Single-line plate: Distance between character and number	30
5.	Dual-line plate: Distance between character row and number row	10
6.	Minimum clearance between character and top-edge and bottom-edge of plate	10
7.	Minimum clearance between character and left-edge and right-edge of plate	10

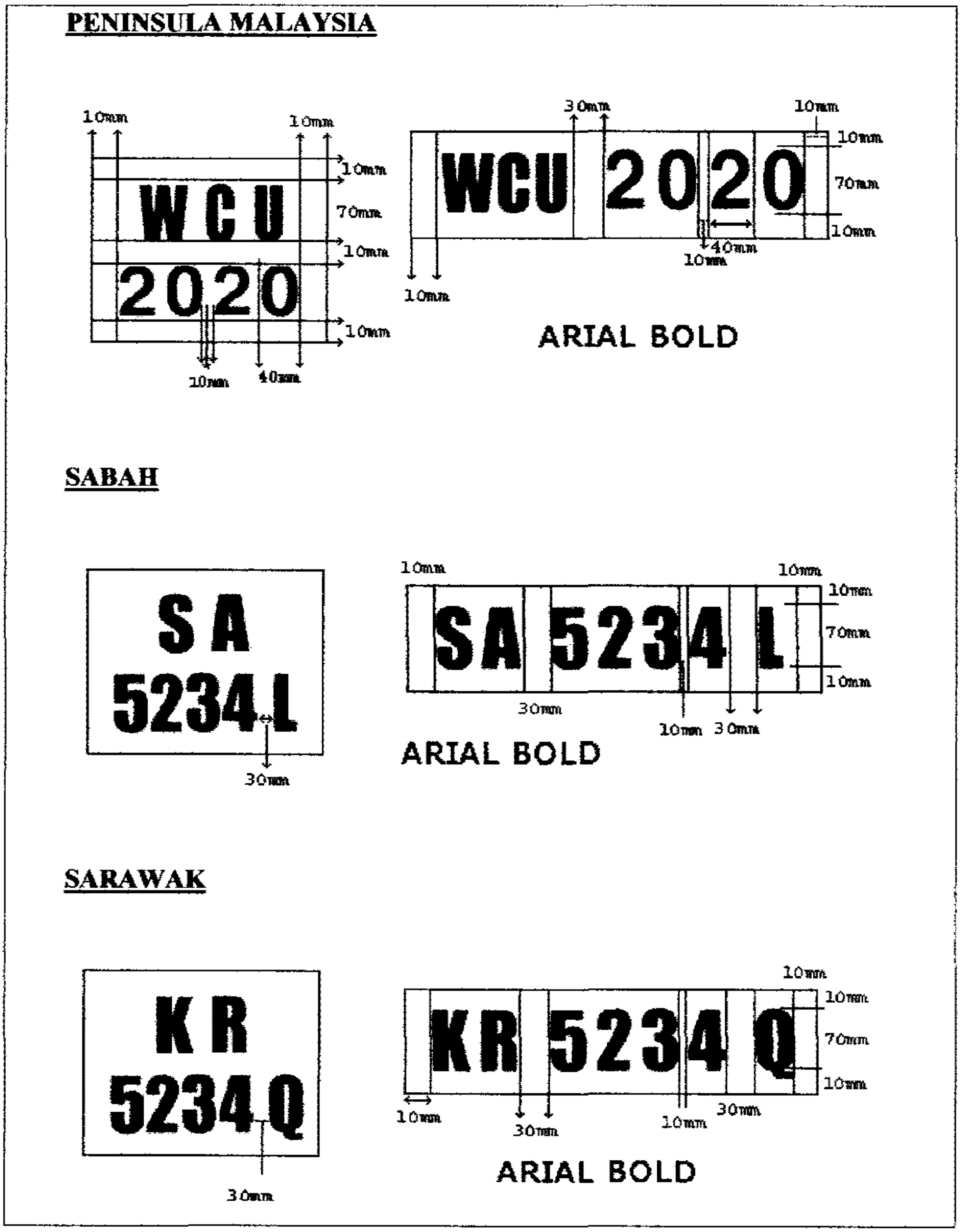


Figure 2.1 Malaysian car plate specifications

2.2 Image Analysis

In computer vision, one of the most important fields is image analysis (Umbaugh, 1998). Image analysis involves data analysis of an image and its purpose is to solve imaging problems in any applications. Therefore, image analysis is a very important aspect in image processing.

Image can be determined as a collection of matrix data. For example, image can be represented in many form such as 2-D or even 3-D. But then, machine vision is used to recover useful information from its 2-D projection. According to (Dept of Physics, University of Edinburgh), the information that is extracted differs from each application. There are many applications that uses the machine vision such as Remote Sensing (satellite images of earth surfaces to detect whether changes or sea surface changes), Inspection and Automation (detecting defects in manufacturing, quality and safety inspection), Medical Imaging (X-Ray image analysis, tumor detection, and blood sampling), and Military applications(aircraft tracking, automated guidance system, and weapons control).

According to (Umbaugh, 1998), the process of machine vision is a continuous process whereby each process or flow is inter-related with each other. The flow/processes of the steps involved in machine vision can be seen Figure 2.2. Each of steps will eventually be explained in further details on Chapter 3: Methodology.

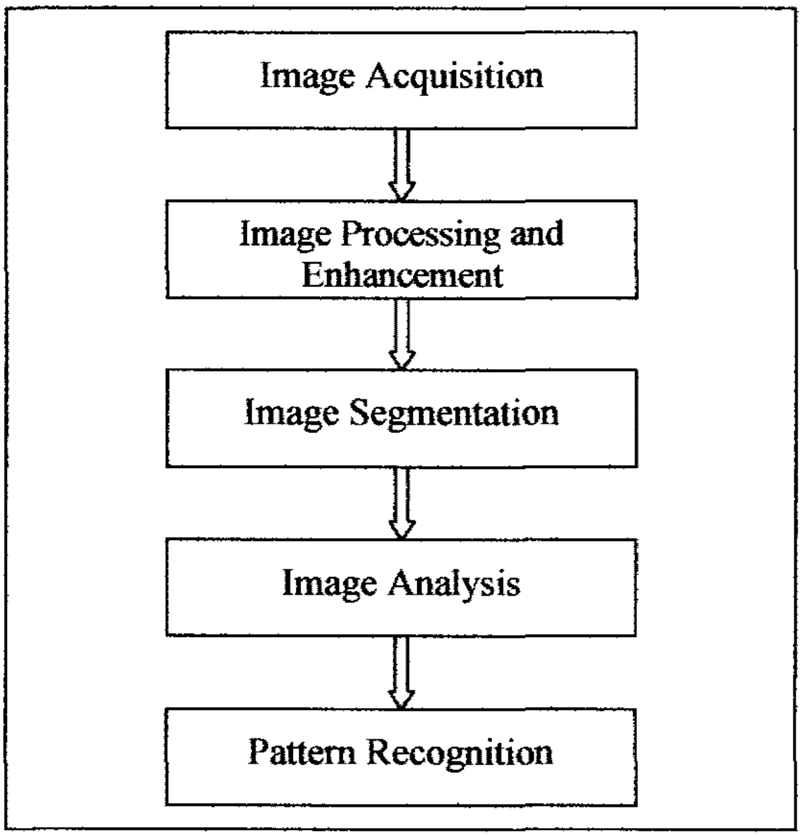


Figure 2.2 Steps involved in machine vision

2.3 Literature Review

Literature review acts as a good source of knowledge for this thesis. This is because by conducting the literature review, it can be said that the starting point in developing this car plate detection system was made easier. By conducting literature review, many aspects of car plate detection were identified including different algorithms and techniques of detection were used by many researchers. Some of the technical document referred was Byongmo Lee and Euiyoung Cha (2002), Fernando Martin and David Borges (1998) and Sorin Draghici (1997).

2.3.1 Complete Recognition System

According to Sorin Draghici (1997) in his research paper entitled *A neural network based artificial vision system for license plate recognition*, the approach used was to scan the image horizontally and look for contrast changes on a scale of 15 pixel[3] and more. He made the assumption that the contrast between the characters are in good view. Figure 2.3 shows the block structure of the whole system researched by Sorin Draghici.

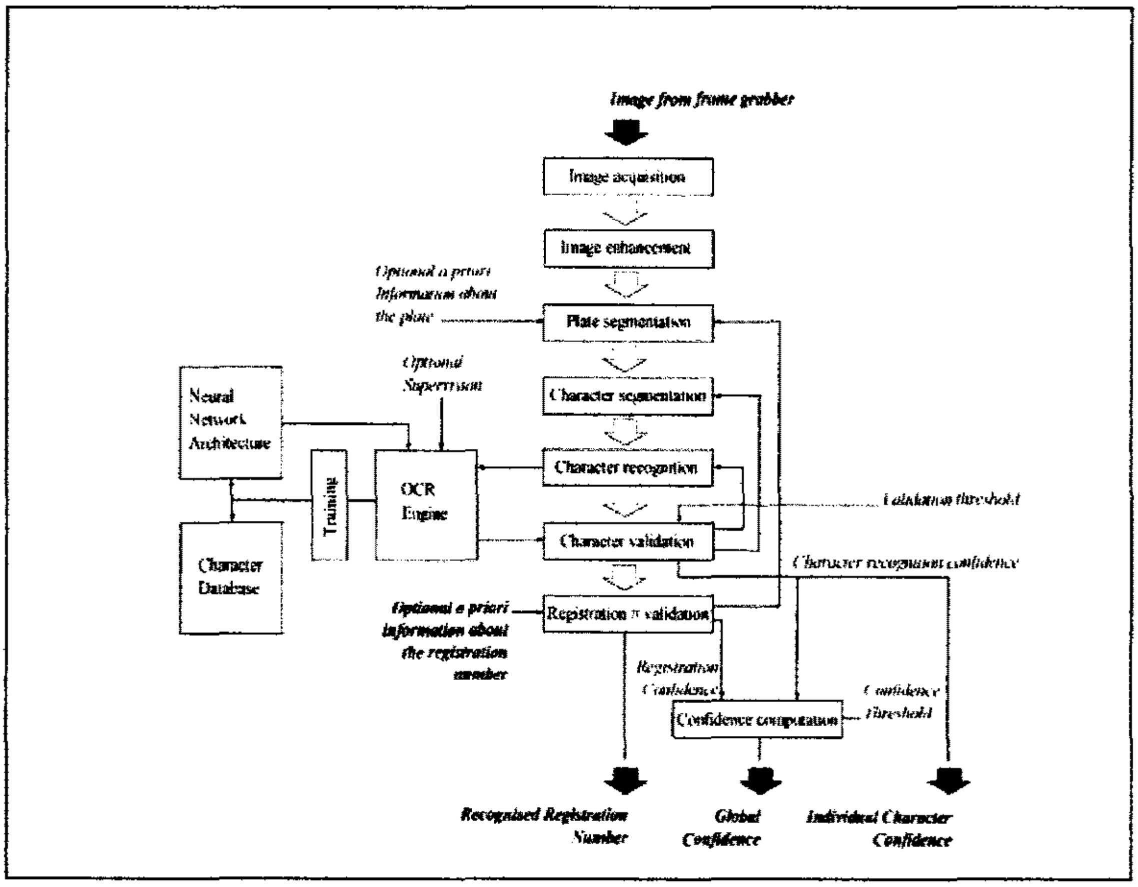


Figure 2.3 Block structure of system researched by Sorin Draghici

As for image acquisition and image enhancement, Sorin Draghici used Gaussion blur filter to remove the necessary noise in the image. The system then calculates and creates a histogram based on the equation and stretches the histogram with:

$$New\_Pixel = (Pixel * gamma) + beta \qquad (2.1)$$

where gamma and beta are calculated so that the stretched histogram will extend on the entire range of grey levels available.

The program then scans the image and searches the high contrast gradient at the given scale. Once done, the scan is repeated to look for concentrations of high gradient area. Therefore, the concentration can be approximated by a rectangle and called interest area. Once the subsequent processing is finished using the same method, the interest areas are enhanced through another histogram stretching. Figure 2.4 shows the sample images produced after the above technique of image enhancement.

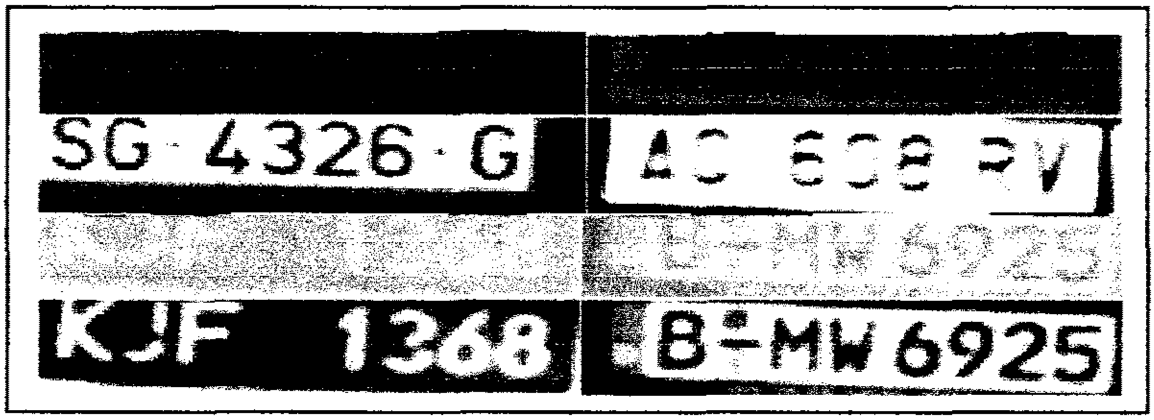


Figure 2.4 Sample images showing result of image enhancement

According to Byongmo Lee and Euiyoung Cha (2002) on their research paper entitled *Fast and Robust Techniques For Detection of Car Plate using HSV and Weighted Morphology*, pixels were extracted in rows and columns. Then, the noises were removed using median filtering. Figure 2.5 shows the flowchart of the plate detection system by this researcher.

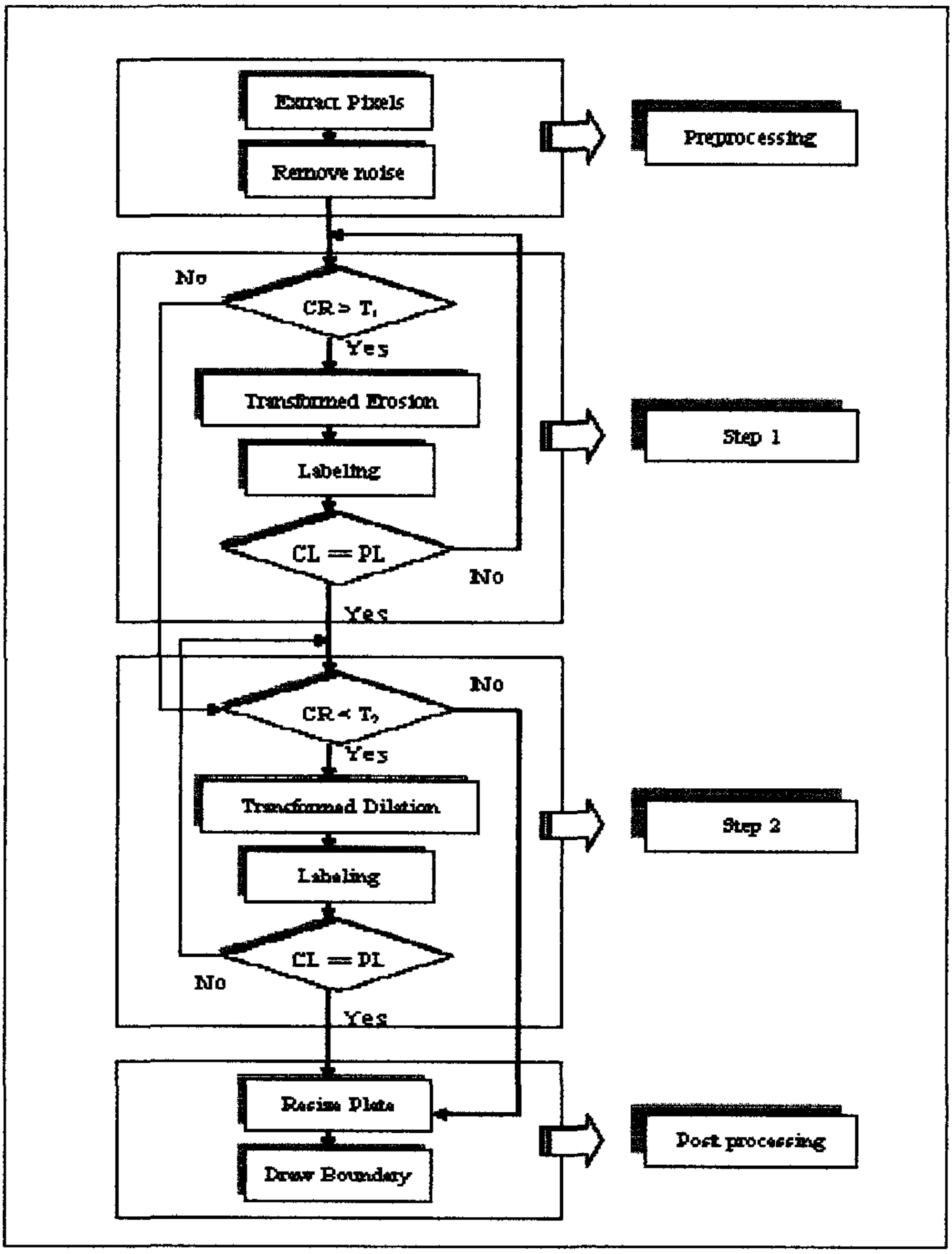


Figure 2.5 Flowchart of plate detection system researched by Byongmo Lee

Since the research was done in Korea, there were only 2 colors of plates in use which was green (private use) and yellow (non-private use). The first step is to find the dominant color of the image, and the other step is to decide the pixel value according to the dominant color. If the dominant color is not yellow or green, pixels with yellow or green was chosen. But if the color is yellow or green tone, yellow or green have to be separated in hue in detail. In addition, the color of blue is dominant in whole image if it was taken in the late afternoon. D_{color} *means* a dominant color in the area, H is the value by hue and T_g, T_y and T_b are a threshold on green, yellow and blue given by experiment.

$$\begin{cases} 60 < H < 160, & \text{count++} \\ \text{Count} > T_g,, & D_{color} = \text{green} \\ 30 < H < 60, & \text{count++} \\ \text{Count} > T_y, & D_{color} = \text{yellow} \\ 180 < H < 210, & \text{count++} \\ \text{Count} > T_b, & D_{color} = \text{blue} \end{cases}$$

$$\begin{cases} D_{color} = \text{green} \ \& \ 30 < H < 140, & \text{BG} \\ D_{color} = \text{yellow} \ \& \ 30 < H < 50, & \text{BG} \\ D_{color} = \text{blue} \ \& \ 30 < H < 180, & \text{FG} \\ D_{color} = \neq\text{blue} \ \& \ 30 < H < 210, & \text{FG} \\ \text{Otherwise} & \text{BG} \end{cases} \quad (2.2)$$

where BG means background and FG means foreground

Meanwhile, Fernando Martin and David Borges in his technical paper entitled *Automatic Car Plate Recognition Using A Partial Segmentation Algorithm* used morphological transformation as a method to perform plate location. In his research, he used the car plates which had a white background and black fonts. To completely locate the plate, the existing result is binarized. Then, using suitable linear S.E (structuring element) the closing was done. This is actually a horizontal line wider than character spacing. This whole process will convert the characters into white rectangle.

After the pre-processing and noise removal technique, Byongmo Lee and Euiyoung Cha used weighted morphology to detect the car plate. Since large cluster is decided as candidate area, the steps were either to reduce the candidate area when it was too large or expand the area if it was large. In order to complete this, 3 steps was taken which was *weighted erosion, weighted dilation* or *post processing.*

In Fernando Martin and David Borges (1998) paper, they used the partial segmentation to extract the characters from the plate. They made the assumption that character pixel is black and background is white and classify plates on square and rectangle one. The plates were classified according to three different borders which are *borders encircle all character, a small part of the border is erased,* and *a small part of the border remains.* After this, border removal was done according to the 3 border classification. Then, by using partial segmentation, co-ordinates of ending of each character, *x* is detected whereby these co-ordinates will be used to define character searching region.

2.3.2 Image Acquisition

According to Gonzalez. C.R and Richard. E.W (2002, there are many ways where images can be acquired. The decision to use any technique is solely based on an individual. For a basic image acquisition technique, digital cameras can be used. This is because digital cameras nowadays has more better image acquiring capabilities like increased digital zoom and fast shutter speed. The advantage of using digital camera is they are cheap and easy to buy.

Another popular method in image acquisition is CCD (*Charged Coupled Device*). The CCD uses broad range of sensing properties and can be packed in rugged arrays of 4000 x 4000 elements or more. The advantage of using CCD sensors is they can reduce the amount of noise that appears in a digital image. Finally, even scanners can be used to acquire the car plate images. This is done by scanning the photographs of car plate images and storing it in a pc. The major drawback of this method is the pictures have to be developed first and the scanning process introduces a lot of noise in the scanned image.

2.3.3 Image Enhancement

Image enhancement is performed on a digital image to improve its overall quality. This is done using noise reduction in which it attempts to recover an underlying perfect image from a degraded image (Peters R.A, 1995). Many techniques applied in noise reduction are by extracting the summation of neighborhood pixels with the density of a pixel in the window at a given location. (Dzulkifli, 1997). This technique is applied using a window with 3 x 3 pixels as in Figure 2.6. The gray level value is stated as G1, G2, G3,... G9 meanwhile the deviational value for each pixels is given as D1, D2, D3,... D9. Therefore, the linear spatial for the window, S is:

$$S = G1D1 + G2D2 + G3D3 + \ldots G9D9 \qquad (2.3)$$

This process is continued by moving the pixels from left to right and towards bottom until the whole image is scanned. The output of this process will give a new value of S.

D_1	D_2	D_3
D_4	D_5	D_6
D_7	D_8	D_9

Figure 2.6 Window with 3 x 3 pixels

2.3.3.1 Mean Filtering

The concept of mean filtering is to produce the average pixel value of a given window with size of N x N. The mean filtering is done using the following algorithm Zalili (2002):

$$S = \frac{1}{N^2} \sum_{(r,c)\in W} d(r,c) \qquad (2.4)$$

Given N^2 is the amount of pixels in window N x N.

2.3.3.2 Median Filtering

The median filtering is under the category of morphological filters. Median filtering is known to be a good filter in removing shot noise or known as salt-and-pepper noise while preserving some edges. When it comes to dense noise, it is not advisable to use this technique because median filtering degrades thin lines and small features Peters R.A (1995). Since number plates represent large features, this technique can be applied in car plate recognition systems.

$$f(x, y) = \underset{(s,t)}{\text{median}} \{ g(s, t) \} \qquad (2.5)$$

Median filtering is better than mean filtering due to lesser blurring effect to the image compared to mean filtering. Median filtering is performed by acquiring the median value of neighborhood pixels in a given dimension like 3 x 3 pixels. The main purpose of median filtering is to ensure that all the neighborhood pixels contain minimal differences in pixel value.

2.3.4 Thresholding

Thresholding is an essential technique in image processing. The main objective of thresholding process is to separate the pixels of a given image into two classes, namely object and background Yakoub (2001). The technique is conducted whereby each gray scale pixels which contain values above the given threshold are put into a one class and vice versa. In short, the whole process of thresholding is converting the image into a binary image. This is because; mathematical manipulation can be done using binary values since each pixel value is either 1 or 0 at a given location.

The gray level values below or equal to this threshold are classified as background, whereas the values above this threshold value are classified as object. Generally, thresholding can be divided into 2 main groups which is global and local Yakoub (2001). In global thresholding, a fixed value is determined as the thresholding value for the whole image. Therefore at any point (x, y) for which $f(x, y) > T$ is called an object; otherwise it is called background. Meanwhile, in local thresholding, the threshold value changes dynamically across the image. The local thresholding method is used when there is poor illumination condition or when the background is uneven.

In general, the global threshold technique can be applied using the following algorithm:

$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) > T \\ 0 & \text{if } f(x, y) \leq T \end{cases} \qquad (2.6)$$

where T is the threshold value.

2.3.4.1 Mean Thresholding

The mean thresholding is performed by calculating the total number of values at each point of the histogram. Each value at histogram represents the values of each pixel at a given location. The values are added and divided by the total number of pixels to produce the mean value. This mean value is then used as the global threshold value.

$$T = \frac{\sum_{j=1}^{n} I(j)}{n} \quad (2.7)$$

where n is total number of values at histogram and *I(j)* is the value of each pixels. After this each pixel lesser than T will be converted into 0 or 1 if the value is greater than T.

2.3.4.2 Median Thresholding

The median thresholding is conducted in a similar way of mean thresholding but instead of acquiring the mean value for T, median value is acquired. The histogram value is arranged in increasing order, X (1) < X (2) < X (3) <.... < X (n) and the median is identified Ron de Beer (1997). After acquiring the median value or now known as threshold value, T, the binary conversion process is conducted.

2.3.5 Plate Location

According to (Duan. T.D *et al.* (2004), one of the most important and difficult part in Vehicle License Plate Recognition system is plate location. There are many method used in locating car plate in an image, such as statistical method, feature extraction, morphology-based, and boundary line-based.

2.3.5.1 Statistical Approach

According to Ashari (1999), statistical approach in detecting license plate is an easy way. In his research, horizontal line-based analysis method is used with coefficient of variation to find the location of the plate number. The approach used in his paper is fixed location of car plates whereby the region of the location was estimated. After extracting the estimated region, horizontal line was drawn from top to bottom. At each horizontal line, coefficient of variation was found and a pattern was identified based on histogram. Finally, the left and right border of the plate was identified using a specific algorithm.

2.3.5.2 Feature Extraction Approach

Feature extraction is another method that can be used during locating car plate in a Car Plate Recognition System. A good process of feature extraction can provide clear view of the patterns available in an image Zalili (2002). A feature extraction technique was researched by Fletcher. L. A, Kasturi. R (2001) whereby morphological approach; dilation and erosion was used. Binary morphological was used in order to differentiate the background and foreground. After performing this, the values in neighborhood pixels are identified and if the values exceed a given region, new pixel value is applied. By performing this process, the newer image is more prominent than the previous image and it is easier to locate the pattern. Finally, plate location and extraction is performed by using algorithm and few sets of range.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Roads in Malaysia are getting filled up from day to day due the large amount of cars and other vehicles paving the roads. This creates a problem whereby vehicle identification is getting more difficult with existing systems around. The best way to identify vehicle is by identifying the number plate. There are many existing car plate recognition systems in overseas but those systems need to be modified in order to apply to the Malaysian car plate formats. Moreover, the cost of those systems is expensive to be applied in our country.

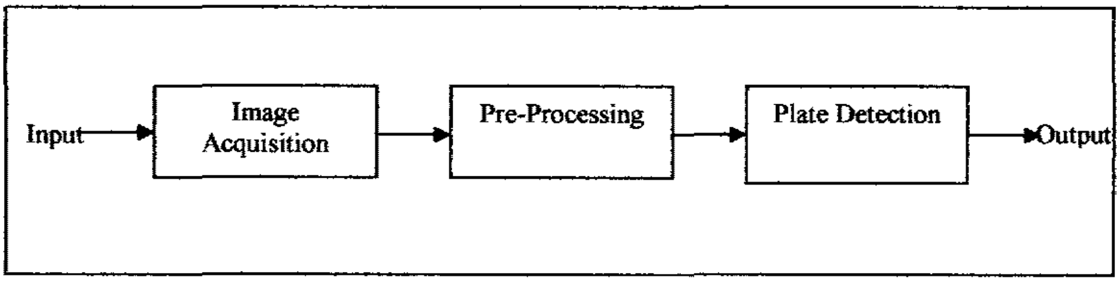


Figure 3.1 Main phases of image processing involved in Car Plate Detection System

Each of these phases is inter-related whereby the first process has to be completed in order to move to the next phase. In short, with the given input the first phase is image acquisition. In this process, images are prepared before being processed. Image enhancement phase is to improve the image quality. This process can be skipped if the quality of the image is good enough. This is because car plate detection is not as sensitive as other image processing applications in terms of image enhancement. Sometimes, image enhancement can be conducted after the whole image is transformed into a binary image.

Thresholding phase are required to convert the given image to a binary image. The conversion process uses specific algorithms in order to provide necessary results. Finally, the plate detection phase is performed to produce the expected output. The plate detection phase actually performed after performing the feature extraction phase. Feature extraction is to show or display the features of image. This will make the process of detection easier and in the case of this research; thresholding is used to produce the features. After this, plate detection is performed using rule-based method.

3.2 Software Development Life Cycle

According to IEEE Standard Glossary of Software Engineering Terminology, the Software Life Cycle can be defined as:

"The period of time that starts when a software product is conceived and ends when the product is no longer available for use. The software life cycle typically includes a requirements phase, design phase, implementation phase, test phase, installation and check-out phase, operation and maintenance phase, and sometimes, retirement phase."

Therefore, Software Life Cycle model or better known as Software Development Life Cycle (*SDLC*) is an abstraction of Software Life Cycle. The

SDLC that was chosen for the development of prototype for Car Plate Detection System was Waterfall Model.

Waterfall model SDLC has been the most famous SDLC model applied. This is because the simplicity of the model allows each process to be finished in order. For example, the second process cannot be initiated until the first phase is completed. In the case of Car Plate Detection System, this is true because each of the phases are inter-related and cannot be skipped. The complete phases involved in Waterfall model is shown in Figure 3.2.

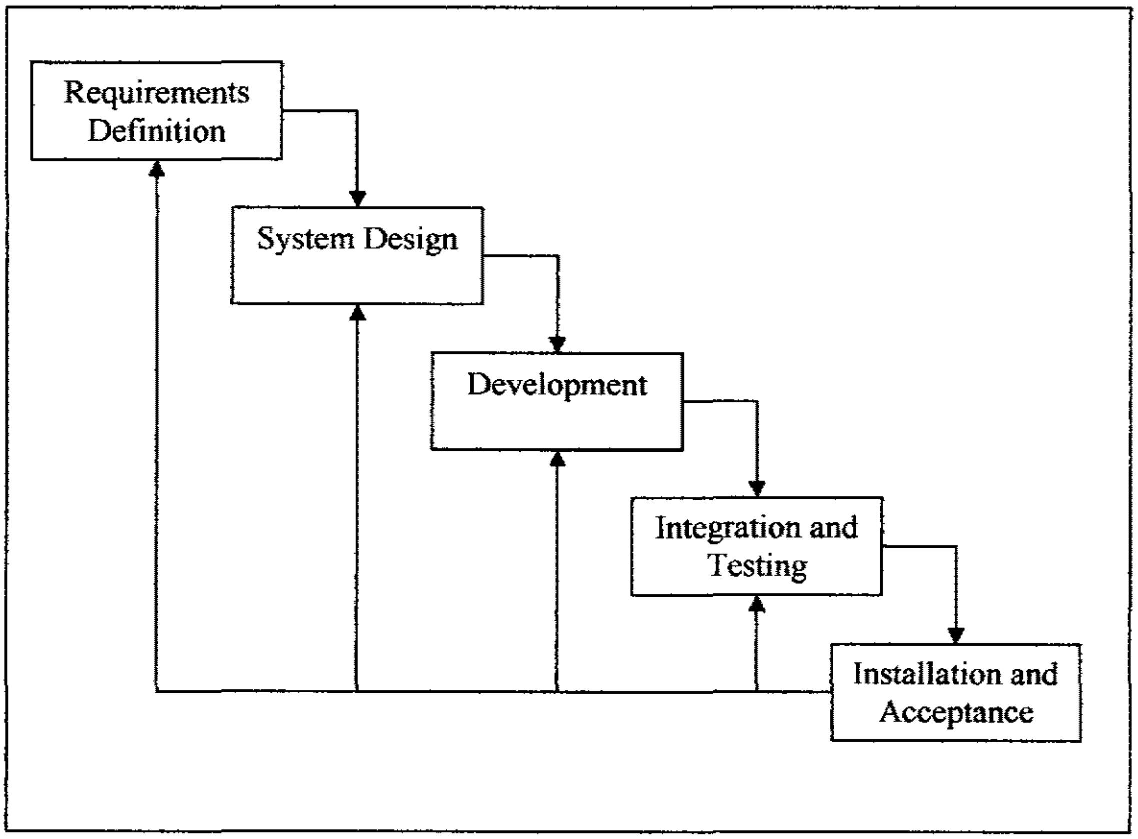


Figure 3.2 The Waterfall Model

3.2.1 Requirements Definition

The requirements definition phase is important because a good requirements study can determine the successfulness of a project. In this research, the phase of requirements study is referred to the literature review. Here, all the necessary information about the research is gathered ranging from necessary information about the image processing phases, steps or algorithms that can be applied at each stage, and the study on the software that will be used to develop the prototype of Car Plate Detection System. Besides literature review, image acquisition phase was conducted.

According to Figure 3.1, the first phase is the image acquisition. This step is important because this phase can be referred as "*stepping stone*" for the whole Car Plate Detection System. The image acquisition phase is important as the images of car plate will be collected in order to perform image processing operations on it. Besides this, the images of car plate will be fed to the Car Plate Detection System engine, so that the image can be read by the system.

For this research on Car Plate Detection System, the images of car plate are acquired using a BENQ Digital Camera with 3.2 Mega pixel zooming capability. As a start, a total number of 50 car plate images were shot. Each of the images taken had a dimension of 640 x 480 pixels and was in JPEG format. The file format of JPEG (*Joint Photographic Expert Group*) was used because the other formats of image were not suitable to be used. BMP (*Microsoft Bitmap*) image was too large to be processed and will use up the disk space meanwhile TIFF (*Tagged Image File Format*) images was not the general image format that used in image processing thus making JPEG the suitable image format for this research.

During the image acquisition process, the camera was positioned 90° and the distance between the plate and the camera was set to 1.5 meters. During this phase, only Peninsula Malaysia's car plate images were used. Meanwhile, the vertical height of the camera, X was not fixed. This is to allow the image of the car plate to appear anywhere in the image. The graphical representation of the camera position during this phase is shown in Figure 3.3.

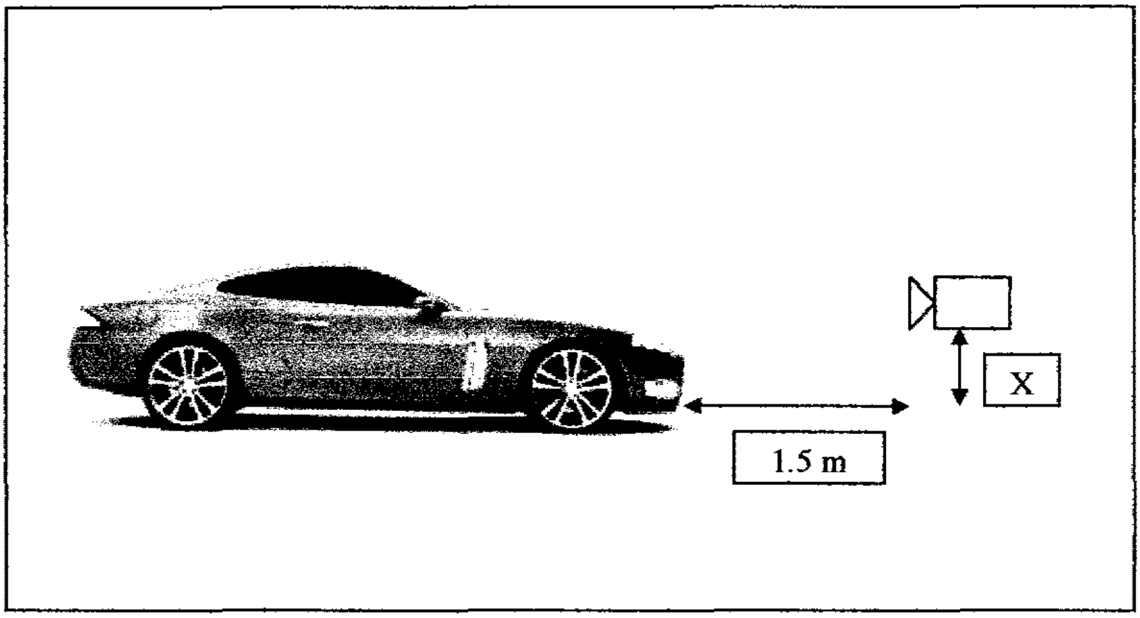


Figure 3.3 Camera position during Image Acquisition phase

After the images were shot, all the images were converted from RGB (*red, green, blue*) image to grayscale image. This process was done with the help of Adobe Photoshop CS (*Version 8.0*). The reason for converting the images from RGB to grayscale is that the grayscale image only contains 1 color scheme or better known as monochrome. With the conversion of the images to grayscale images, it is easier to do operations on image because the matrices that is produced are easier to be calculated because each pixels only holds one value compared to the original image that is RGB which holds 3 values for each pixels. The sample images of car plate are shown in Figure 3.4.

Figure 3.4 Sample images of car plate taken under Image Acquisition phase

3.2.2 System Design

The system design phase is conducted after completion of the requirements definition phase. This phase involves the planning of how to develop the system which includes all the system interfaces, data dictionary, and flow of the system. This phase is conducted so that the next phase is easier to be executed. With a detailed view of the system and a good data dictionary, it will be easier to perform the programming techniques. For the Car Plate Detection System, the system design is performed by identifying the flow of the system and choosing the proper algorithm to be applied in the development phase.

In this phase, system design was in 2 different parts. This was pre-processing and Plate Detection and is discussed in detail inside. The design was crucial because each of the sub-modules involved are linked or inter-related to each other. Therefore, the whole process in designing and developing this system had to be conducted step by step. The image acquisition phase was conducted during the requirement analysis phase as it involves only capturing of car plate images. The rest of the Car Plate Detection System phases were developed under the development phase.

3.2.2.1 Pre-Processing

For the Car Plate Detection System, 2 processes are involved in pre-processing which are thresholding I and filtering. This process is crucial because the output of this processes are used as the input for the next phase; feature extraction. Figure 3.5 shows the process flow involved in pre-processing phase.

In this research, the digital image that was taken is fed into the system. The process of converting the image to digital image is performed first. Only after that, the filtering process is done to remove unwanted pixels.

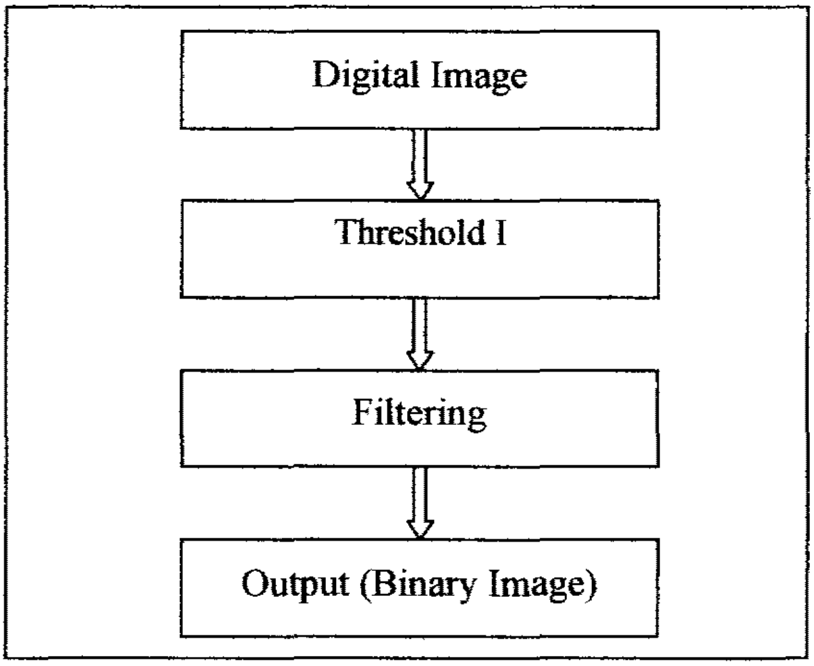


Figure 3.5 Pre-Processing phase in Car Plate Detection

a. Threshold I

Thresholding phase is the phase where the first processing of image takes place. Thresholding is the process of converting the existing grayscale image to binary image. It is understood that direct conversion from of original image to binary image is difficult and this is where the thresholding phase comes in. It is difficult because the original grayscale image contains matrices in *unit 8* format. This format does not allow for certain processes to be executed and therefore these matrices must be converted into a format where normal mathematical operations can be executed. Therefore, the existing *unit 8* matrices are converted to *double* matrices so that the thresholding phase can be performed. After conversion, the thresholding algorithm is applied to the matrices.

According to Awcock and Thomas (1996), the thresholding technique applied on an image must satisfy 3 rules. These rules are automatic, fast and powerful. The automatic thresholding is that there should not be any human inputs during the thresholding process and it must be fast enough to process the pixel values. The thresholding process must be capable to produce a clear image that can be divided into foreground and background. Finally, the thresholding value must be a proper value in which it can produce the binary image that can be further processed.

In this research, global value threshold, T is applied to the car plate images. If the grayscale pixel value of the image, $f(x,y)$ is equal or less ($f(x,y) \leq T$) than the threshold value, it is classified as background meanwhile the value more than the threshold value ($f(x,y) > T$) is considered as object.

Since the car plate image was taken from a given distance, they chances for background to uneven due to poor illumination condition is less and therefore global value threshold method is preferred. After testing using some sample images, it is found out that the threshold value had to be decided manually. This is because the images acquired had different illumination value and this restricts the usage of *mean* *or median thresholding*. As a result, Adobe Photoshop was used to determine the threshold value.

When a threshold value is applied in an image using the algorithm (3.1), a histogram can be produced. Optimal threshold value can be decided using this software and as a result, a global threshold value, T of 135 was decided to be applied. After acquiring the value of *T*, the grayscale image now can be converted into a binary image. All the pixel values which are lower than the value of *T* are assigned with the value of 0 meanwhile for all pixel values which are more than the value of *T* are assigned with 1.

$$G(x,y) = \begin{cases} 1; \text{ if } f(x,y) > T \\ 0; \text{ otherwise} \end{cases} \quad (3.1)$$

where G(x,y) is the new pixel value and *T* is the global threshold value.

b. Filtering

Image enhancement phase is conducted to improve the quality of image. Quality here is referred to the quality of pixels in the image. When a image is captured, there are chances for the image to contain unwanted pixels or better referred as noise. The existence of noise in an image will eventually delay the processing of the image because after processing, the results might be different than the results that suppose to be. Therefore, it is essential to remove unwanted pixels in the image.

Since the thresholded image contains minimal noise, image enhancement phase had to be conducted. This will allow a better and noise-free image so that the feature extraction can be successfully applied. A choice was made between the *mean* *filtering* and *median filtering*. After a careful study, *median filtering* was decided because this method filters the noise better than the other method. Moreover, *median filtering* restores the image quality whereby the level of blurriness is lesser compared to *mean filtering*. The sample command in Matlab used for *median filtering* is as (3.2).

$$B = \text{medfilt2}(A,[m\ n]) \tag{3.2}$$

whereby A is the 2-dimensional matrix and m and n are integers values which denotes the neighborhood pixels in which the filtering is done. For example, if m=3 and n=3, then the filtering is done on a 3 x 3 neighborhood pixels.

After the filtering, the result of the image is reduced noise. Therefore, feature extraction can be performed to produce a better result. The result of pre-processing will be discussed in Chapter 4 in detail.

3.2.2.2 Plate Detection

The plate detection phase involves 3 process; feature extraction, thresholding II, and location detection. All these processes are essential because the result of these phase produces the real output needed.

The feature extraction process is done to extract the features from the binary image. Meanwhile, the thresholding II is conducted to change the pixel values so that the features are more prominent. Finally, location detection is performed to find the location of the car plate. The details of plate detection phase is shown in Figure 3.6

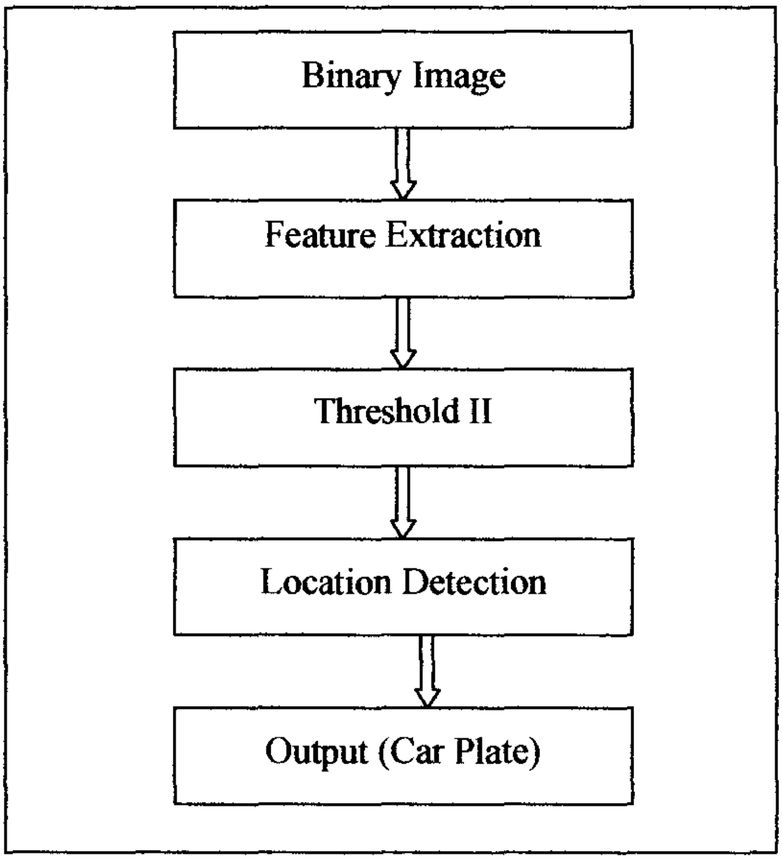


Figure 3.6 Plate Detection phase in Car Plate Detection

a. Feature Extraction

After the converting the image into binary image, the image is transferred to another module whereby feature extraction is performed. In this module, feature extraction is performed using segmentation. The idea in this module is to divide the big image into smaller segments so that the features are easier to be manipulated. Since the whole image is at a dimension of 640 x 480 pixels, the whole image was divided into smaller windows of a constant size. The image was divided into 64 small windows horizontally and 48 windows vertically. Figure 3.7 shows the division of the whole image into smaller windows.

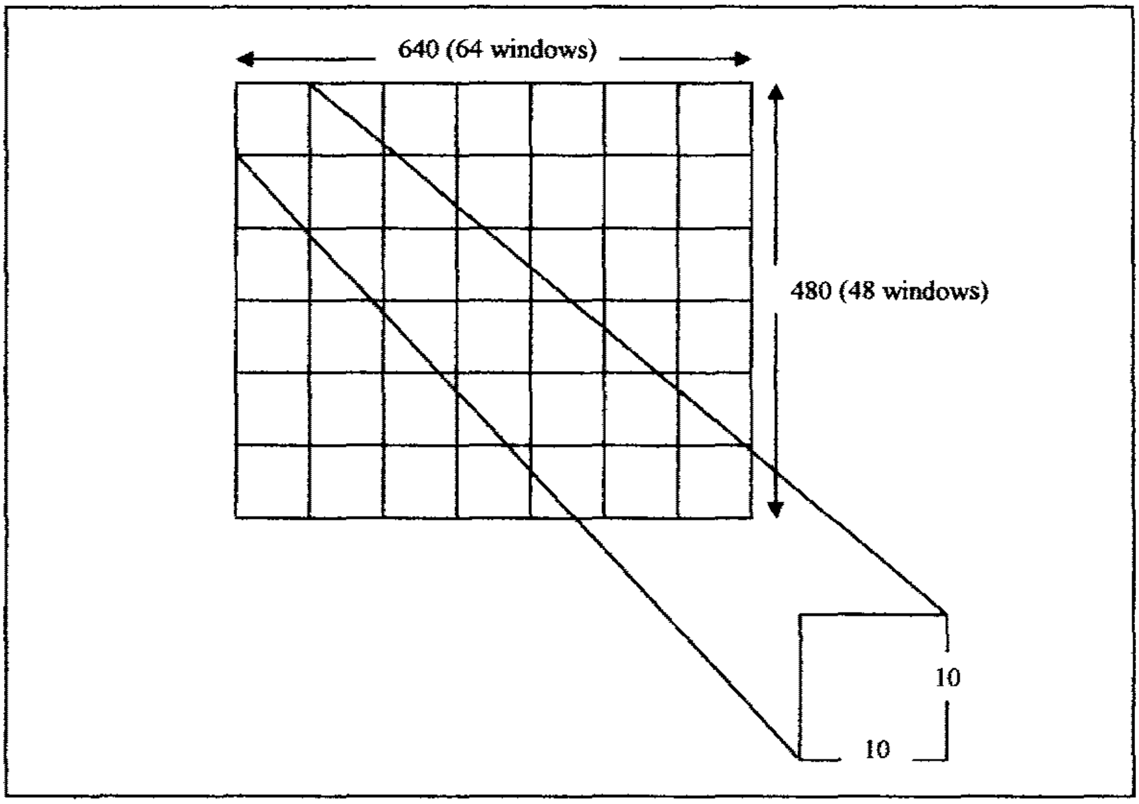


Figure 3.7 Division of image into small windows

After the division into smaller images, the whole image is now filled with 3072 small windows measuring 10pixels x 10 pixels. Each of these small windows now contains a total number of 100 data or pixels. The purpose of dividing the images into such a small window is because each car plate measures at least 160 pixels by 40 pixels due to the distance of 1.5 meters between the camera and the plate during image acquisition. These values were analyzed and obtained using Adobe Photoshop CS.

After estimating the car plate dimension on the real image, it was decided that the image is divided into smaller parts in which these small parts will fit into the car plate image. In short, the small window measuring 10 x 10 pixels will fill the car plate size of 160 x 40. Assuming that the division of the small window fits exactly on the car plate, it will require at least 10 x 4 small windows to cover the plate. Figure 3.8 shows sample car plate image with 3 x 3 small windows covering the plate.

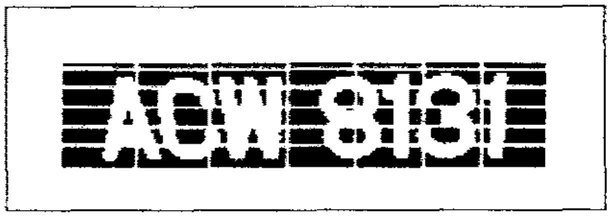


Figure 3.8 Sample car plate showing 7 x 5 small windows

Since the image has been thresholded, the binary image is divided accordingly. The purpose for the division into smaller images is to calculate the total sum of 1's and 0's in each of the small window. Given each window measures 10 pixels by 10 pixels, it can be concluded that the maximum value for the sum that can be attained in this small window is 100. This value can be either for pixels with value of 1 or 0. During the image thresholding process, it was decided that pixels representing white was assigned with value of 1 and 0 with black. Based on this, it can be concluded that the total sum of 100 data in the small window can be fully black or white based on the value of pixels at a given coordinate.

b. Threshold II

After calculating the sum of 1's and 0's in each of the window, the whole matrix of small windows can be displayed. Since the car plate image contains big regions of black in an image, a new thresholding process need to be performed. Slightly different compared to the previous thresholding technique; thresholding I, the new technique is performed to remove the values that equals to 100 and occurs continuously for 4 times.

This is because, after the first thresholding, car plate characters will be visible in white and the background as black. Knowing this, it can be concluded that, if a small window produces a sum of 100 for pixels with value 0's then, it can be said that this window is not a part of the car plate. This is because when a character in a plate falls into small portion of any of these small windows, then the sum of pixel with 0's will be lesser than 100.

c. Location Detection

After performing the thresholding for the second time, plate location process can be started. The idea of detecting the plate is based on rules. This is because the pattern or feature of the image is more prominent to our naked eye. Using this as a guideline, rules for plate extraction can therefore be set.

Since Malaysian car plates have a specification set by the Road and Transport Department of Malaysia (JPJ), it is easier to set the rules. During the literature review, it has been stated that in a single-line car plate, the distance between last character and the first number in the car plate has to be 30mm. Figure 3.9 shows the distance between the character and the number in a car plate.

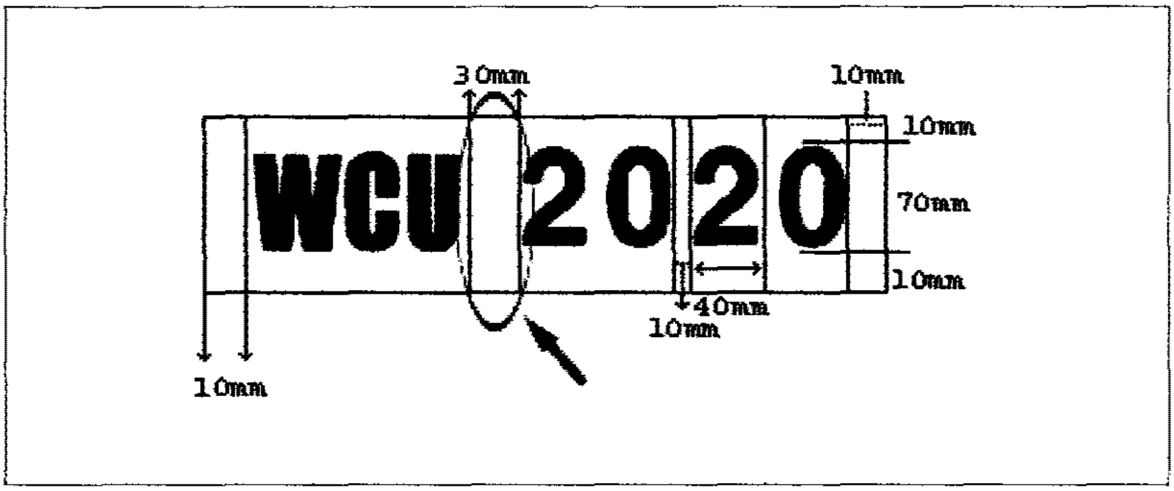


Figure 3.9 The distance between the last character and the first number

After knowing the measurement, the distance now can be used in setting up the rules. After thresholding the image into binary and performing the feature extraction, the gap between the character and the number will remain as black and this portion has a width of 30 pixels and height of 50 pixels. Based on this dimension, it can be concluded that it will require 3 x 5 small windows to fill this portion.

The thresholding for the second time will preserve this area because the threshold is performed only on parts whereby the sum of 100 repeats as many as 4 times. An algorithm is created whereby the each pixel in the image is checked for the sum of 100. After finding the value, the neighbors of this pixels is checked whether it meets the condition for the distance between the character and the number.

After condition is fulfilled, the original image needs to be extracted. This process need to be done because the all the mathematical operation conducted was on binary image and on windowed image. Since at the initial stage, the whole image was converted into 64 x 48 small windows, the location of the plate on the real image need to be found. Therefore, adjusting the pixel values need to be performed so that the small windows can be mapped into the real image so that the exact location of the plate can be detected.

3.2.3 Development

The development stage involves in producing the output but without the testing. This phase involves all the code programming, database programming and also the development of interface. In this research, the development was done using Matlab 6.1 for all the programming of image processing. All the algorithms studied are applied in the form of programming code. Unfortunately for this research, database programming is not involved as this system is only developed as a prototype. All the pre-processing phases are stored separately as Matlab work file (*e.g.main_ threshold.m*). Besides this, the unit testing is also performed during this stage. Once each phase of pre-processing is completed, the module is tested with different images of car plate to verify the output and fix any bugs in the code.

Matlab was chosen as the programming language because this software supports the image processing coding. This software also supports the C coding. Besides this, the software also provides built in library functions. One good example is the built-in function for median filtering. Moreover, this software supports the manipulation of images in the form of matrix. As a result, Matlab Version 6.1 was used in the development phase.

3.2.4 Integration and Testing

This phase is mainly purposed for testing and validating the whole system integrity. Besides this, all the modules are put together and integrated. This process can be called as link testing. After successfully completing the integration testing, system testing is conducted. Here, the whole system is test from scratch ranging from data inputs; output of the system and the system is able to cope with most of the operational conditions.

Generally, live data is used to perform the system testing. As in the Car Plate Detection System, the integration testing is performed by combining 2 modules together and check the system. For example, the image acquisition phase is combined with thresholding phase and these 2 modules are tested to see whether they can produce the necessary calculations. Finally, for the system testing, the whole Car Plate Detection System is tested from the beginning. The system testing was conducted using 50 images of car plate and the results are discussed in Chapter 4.

3.2.5 Installation and Acceptance

During the installation and acceptance phase, all the system modules are tested and accepted by the customer. Successful execution of the test phase is the pre-requisite to acceptance of the software by the customer. In this research, the installation and acceptance is performed based on the acceptance of the system prototype by the supervisor.

3.3 Software Requirement

The software item that is used in the Car Plate Detection System is shown in Table 3.1.

Table 3.1 : Software Requirement

Item Type	Detail Description	Version	Purpose
Operating System	Ms Windows XP Professional	Version 2002	OS for Notebook
Notebook Software	Ms Office XP	Office Professional	Produce thesis and other documentations
	Ms Project XP	Office Professional	Produce Gantt Chart
	Adobe Acrobat Reader 7.0	Version 7.0	Read online materials and references
	Norton System Works 2003	2003	Protect the computer from threats
	MATLAB 6.1	6.1	Development tool

3.4 Hardware Requirement

The hardware items that is used in the Car Plate Detection System is shown in Table 3.2

Table 3.2 : Hardware Requirement

Item Type	Detail Description	Purpose
Notebook	• Intel Centrino 1.5Ghz processor • 256 MB RAM • 30GB Hard Disk Space	Development
Digital Camera	• BENQ DC 2300 • Built in CCD Sensor • 3.2 Mega Pixel digital zoom	Image Acquisition

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

After the completion of the Car Plate Detection System prototype, all the car pictures that were taken were put to the test. Each module or phases of the system produced the relevant results. The results from each phase were discussed in detail in this chapter.

4.2 Results of Image Acquisition

The image acquisition phase was to capture car images which show the car plate in it. Therefore, for this phase, a total number of 50 images were taken using digital camera and all the car plate images are attached in Appendices. Each image was at a size of 640 x 480 pixels and in JPEG format and grayscale. The car plate images were taken from the front side of the car and the whole process of image acquisition were limited to only car plate images. As an example, Figure 4.1 shows 4 sample images of car plate taken.

Figure 4.1 Sample images of car plate.

4.3 Results of Threshold I

After the image acquisition phase, the car plate image is fed into the system and the first process that is performed is thresholding I. Here the image is converted from a grayscale into a binary image whereby each pixel holds only 1 value that is either 0 or 1.

When the original image is fed into the system, the Matlab reads the image as a unit8 format. Therefore, in order to manipulate the values, the image is converted to double format so that the thresholding process can be performed. Figure 4.2 shows the sample of 2-dimensional matrix values for the original image. Meanwhile, the matrix value after thresholding is shown in Figure 4.3. The sample thresholded images are shown in Figure 4.4.

8	8	8	8	9	9	9	9	8	9
9	9	9	9	9	9	9	9	8	9
10	9	9	9	9	8	9	8	8	9
9	9	9	9	9	9	9	9	9	9
9	8	8	9	9	8	9	9	8	8
10	9	9	9	10	9	9	9	9	9
9	9	9	9	9	9	9	8	9	9
9	8	9	9	9	9	10	8	10	10
9	9	8	9	9	9	9	10	9	9
9	9	9	9	9	9	9	10	9	10

Figure 4.2 2-dimensional matrix values for the original image.

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Figure 4.3 2-dimensional matrix values for the thresholded image.

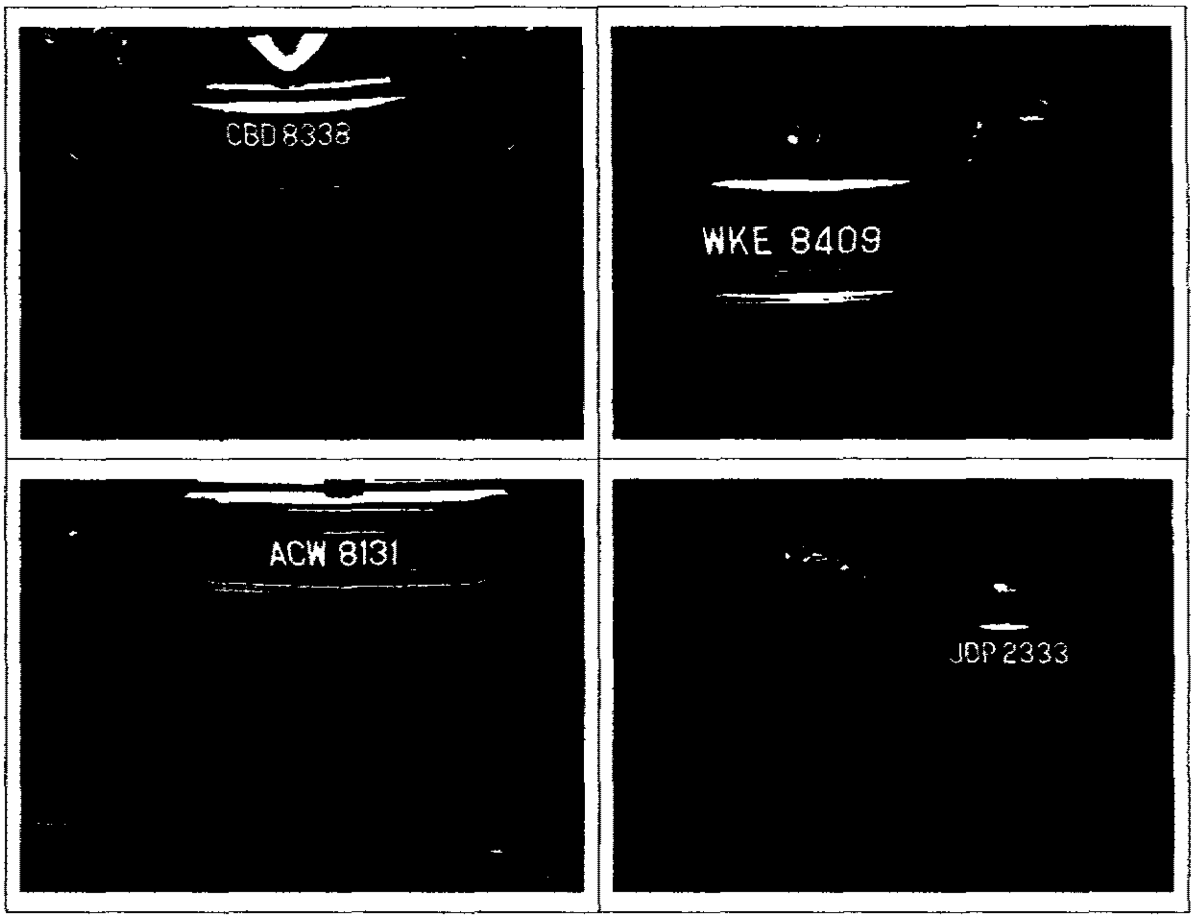


Figure 4.4 Images that has been thresholded using global value threshold

4.4 Results of Filtering

Due to the amount of noise existed after converting the image into binary, a filtering process was done. The technique used was median filtering because this technique prevents the image to appear blurring. The sample in Figure 4.5 shows the thresholded image before and after filtering.

Figure 4.5 Thresholded images before and after filtering

4.5 Results of Feature Extraction

After the prototype system produce the binary image, the binary image is transferred to another module whereby feature extraction is performed. In this module, feature extraction is performed using the mathematical method. Since the whole image is at a dimension of 640 x 480 pixels, the whole image is divided into smaller windows of a constant size. The image was divided into 64 small windows horizontally and 48 windows vertically. Figure 4.6 shows the division of the whole image into smaller windows.

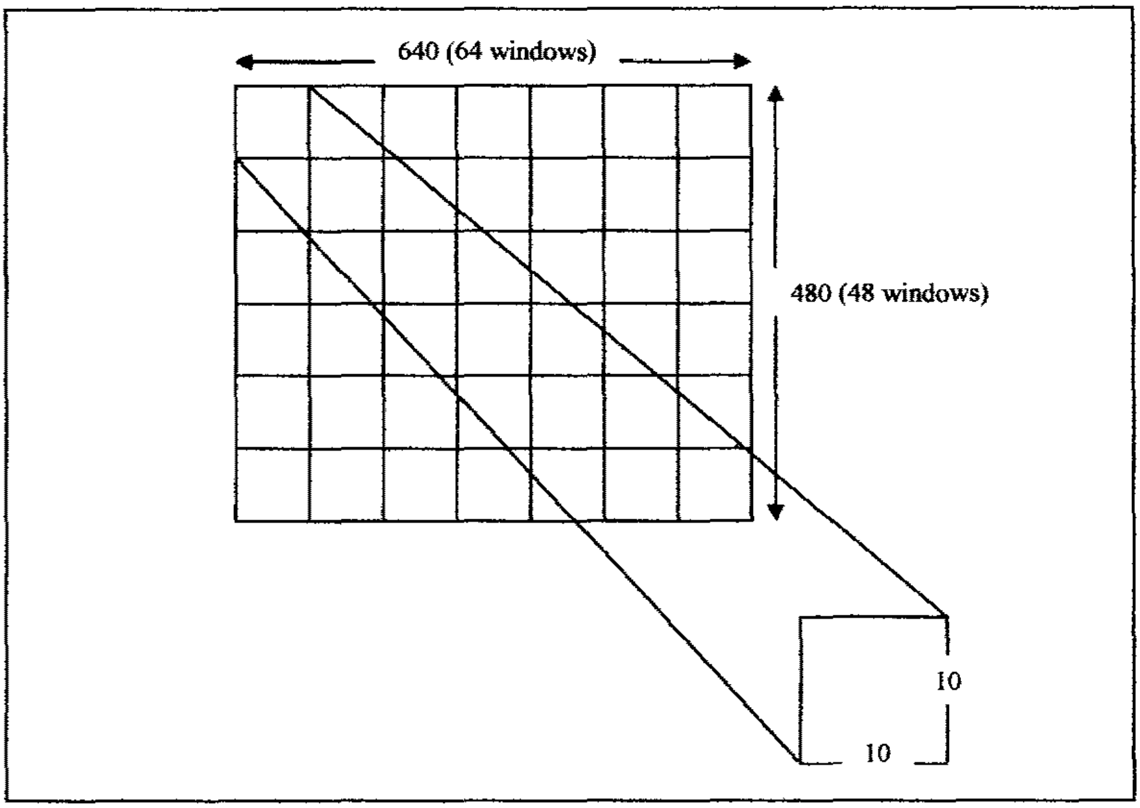


Figure 4.6 Division of image into small windows

After the image is divided, the result will be 64 x 48 windows which will be a total of 3072 small windows. Each of these small windows is in size of 10 x 10 pixels. From here, the total amount of pixels in each of the small window is counted whereby separate variables hold the value of black pixels and white pixels. Since a small window measures 10 x 10 pixels, the maximum value of data in this window will be 100. If this value exists, then the small window is either entirely black or white. Figure 4.7 shows the values of sum on the area where the plate resides.

100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
100	100	100	88	100	100	100	100	85	70	70	70	70	70	70	78	78
100	100	70	60	49	46	39	49	50	100	44	38	56	42	49	56	35
100	100	50	45	49	100	60	8	40	100	37	28	72	67	74	49	48
100	100	43	36	44	53	48	45	40	100	49	42	65	47	52	53	52
96	100	96	99	97	94	99	97	96	100	100	92	100	100	96	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
75	74	79	70	72	75	70	70	70	69	64	60	66	70	70	70	70
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Figure 4.7 The sum of values for small windows where the plate resides

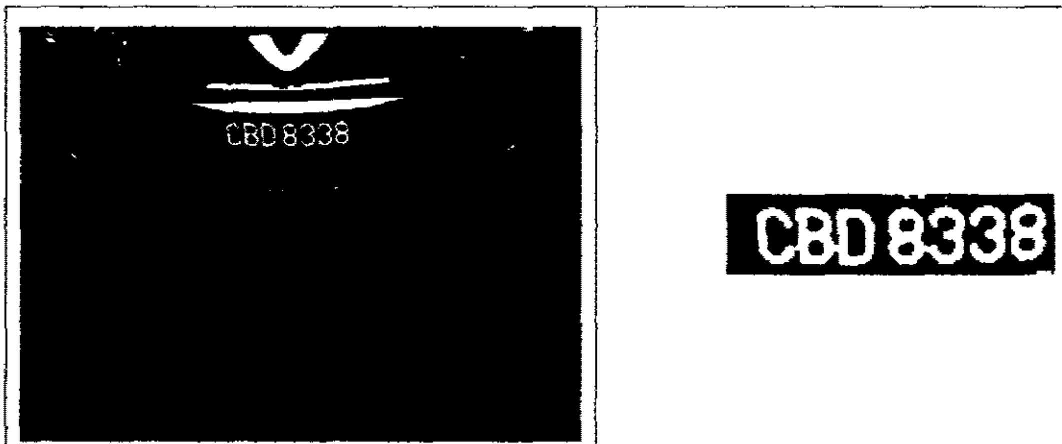
But, in this research, black windows are the ones looked for since car plate character is represented with white pixels. Therefore, when an output of 100 is shown continuously for 4 times, the sum is converted back into value of 0. The repetition of 4 is chosen because through studying each image, the maximum width between the character and the nearest number can only be 3 small windows or 3 repetitions of 100 as the sum. Therefore, whichever repetition exceeds 3, it can be concluded that the region is not the plate divider. This process is called thresholding and is shown in Figure 4.8. This process is performed to produce the feature and it is easier to set the rules.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	100	88	100	100	100	100	85	70	70	70	70	70	70	78	78
0	0	70	60	49	46	39	49	50	100	44	38	56	42	49	56	35
0	0	50	45	49	100	60	8	40	100	37	28	72	67	74	49	48
0	0	43	36	44	53	48	45	40	100	49	42	65	47	52	53	52
96	100	96	99	97	94	99	97	96	100	100	92	100	100	96	100	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	74	79	70	72	75	70	70	70	69	64	60	66	70	70	70	70
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4.8 Car plate areas after thresholding

After removing the sums that equals to 100, the feature of the plate is more prominent. Therefore, it is easier to locate the distance between the last character and the first number in the car plate. Referring to Figure 4.5, the region or distance between the character and the number is clearly visible as there are values of 100 repeating vertically. This area is denoted as the area of the distance between the character and the number.

Since it is known that this region appears, the rules for detecting this area can be set. Firstly, when the sum of 100 is detected in the thresholded 2-dimensional matrix, the immediate neighbors of this pixel are checked. Given that the neighbors are in the region, then the neighbors are checked again tom verify their values. Finally when all the rules are fulfilled, the 4 coordinate of each corners are taken into account. Then, these coordinates are mapped and converted back to the coordinate of the real image. This therefore produces the image location as shown in Figure 4.9.



(a) (b)

Figure 4.9 Output of feature analysis (a) Thresholded image, (b) Extracted car plate

4.6 Constraints

A number of constraints were faced during the development of *Car Plate Detection System*. The main constraint was the difficulty in detecting the car plate. This is because the car plate can be anywhere on the image. Besides that, certain images could not be thresholded properly due to the dark background and shadows. This eventually failed to produce the desired output. Other than that, the size of car plate varied a little due to the size of the vehicles. For example, the size of a Kancil's car plate slightly differed from the Wira's car plate size. The size difference occurred only in images.

4.7 Further Research

Further research can be done for this *Car Plate Recognition System*. There are still a number of researches can be conducted on this research. Below are the lists of future research that can be conducted under this topic:

a. The current system was only focused for car plate numbers.
b. The images taken was from a still shot and not from moving car.
c. Most of the images of car plates used were only the images from a single line car plate.
d. The double line car plate images were not tested.
e. Only few algorithms were tested for each phase of preprocessing.
f. This research is limited up to only pre-processing phase.
g. The plate segmentation and character recognition were not part of this research.

CHAPTER 5

CONCLUSIONS

5.1 Introduction

The purpose of this research was to apply the techniques of image processing for a car plate detection system. Although the real system was not developed and tested, a small scale prototype was developed to be tested and apply these techniques. The prototype system of *Car Plate Detection System* had 4 major parts which are Image Acquisition, Image Filtering, Image Thresholding, and Plate Detection and Location. A total number of 50 images were used for testing and the summary of the results are shown in Table 5.1.

Table 5.1 : Summary of Testing

No.	Testing Data	Value	Percentage (%)
1.	Successful Plate Detection	39 / 50	78
2.	Failed Plate Detection	11 / 50	22
3.	Correct Location of Plate	34 / 39	87.2
4.	Incorrect Location of Plate	5 / 39	12.8

5.2 Image Acquisition

The image acquisition phase was to capture car images which show the car plate in it. Therefore, for this phase, a total number of 50 images were taken using digital camera with a size of 640 x 480 pixels and in JPEG format and grayscale. The sample images taken and tested are attached in Appendix A.

5.3 Threshold I

This phase was conducted to transform the current grayscale image into a binary image. To convert the image, a threshold value was identified using the manual method using Photoshop. Therefore, a global threshold value of 135 was decided as an optimal value for the image condition. A check was conducted from the first pixel and if a pixel exceeds the threshold value, it was converted into 1 or 0 if otherwise. The image is now ready for the next phase where plate detection was conducted.

5.4 Filtering

Filtering was performed to remove unwanted noise. The additional pixels existed after the image was thresholded. Therefore, filtering using *median filtering* was used. This technique removes the unwanted pixels by checking the neighborhood pixels.

5.5 Feature Extraction

Feature extraction is performed using the *segmentation* technique. The original image of size 640 x 480 pixels is segmented into smaller windows measuring 10 x 10 pixels. After segmentation, the sum of the pixels is counted and a new 2-dimensional matrix is performed. This is to show the feature of the original image, so that plate detection can be performed.

5.6 Threshold II

The thresholding used for the second time is different in sense that it does not convert the image to binary, but makes the features of the binary image more clearly visible. Pixels with value of 100 are converted to 0 so that the location of the car plate can be detected easily.

5.7 Location Detection

Location detection is the final process in the plate detection phase. This process produces the required output; the car plate. The location detection is performed by identifying the gap between the last alphabet and the first number on a plate. If the condition of the pixels satisfies the rules, then location is identified and the plate is extracted from the binary image. Out of 50 images tested, the successful plate detection was 78%. Out of these 39 successfully detected images, a total number of 34 or 87.2% were the correct car plate.

5.8 Conclusion

As a summary, there are many car plate detection systems available in the market. This prototype was developed just to show how the image processing techniques are applied. Although the prototype was not developed to perform until character recognition, the prototype clearly showed the powerfulness of image processing techniques and was able to fulfill the research objectives.

REFERENCES

Draghici, S. (1997). *A neural network based artificial vision system for licence plate recognition.* Dept. of Computer Science, Wayne State University.

Duan, T. D., Duc, D. A. and Du, T. L. H. (2004). Combining Hough Transform and Contour Algorithm for detecting Vehicles. License-Plates. *2004 International Symposium on Intelligent Multimedia, Video and Speech Processing.* October 20-22

Gonzales, R. C and Woods, R. E. (2002). *Digital Image Processing.* 2^{nd} ed. Upper Saddle River, N. J.: Prentice-Hall, Inc.

Lee, Byongmo. and Cha, E. (2002). *Fast and Robust Techniques for Detection of Car Plate using HSV and Weighted Morphology.*

Liau, P. S., Chen, T. S. and Chung, P. C. (2001). A Fast Algorithm For Multilevel Thresholding. *Journal of Information Science and Engineering.* 17: 713-727.

Martin, F. and Borges, D. (1998). *Automatic Car Plate Recognition Using Partial Segmentation Algorithm.* Signal Theory and Communication Department, Vigo University, Spain.

Mohamad Ashari Bin Alias. (1999). *Pengesanan Kedudukan Nombor Plat Kereta Menggunakan Pendekatan Pekali Variasi.* Universiti Teknologi Malaysia: Bachelor. Thesis.

Norton-Wayne, L. (1995). The Automated Inspection of Moving Webs Using Machine Vision. *IEEE Colloquium On Application Of Machine Vision.* 3/1 - 3/8.

Peters, R. A. A New Algorithm For Image Noise Reduction using Mathematical Morphology. *IEEE Transaction on Image Processing.* 4(3): 554-568.

Petrakis, E. G. M. (2001). *Machine Vision.* Department of Electronic and Computer Engineering, Technical University of Crete.

Sezgin, M. and Sankur, B. (2004). Survey over image thresholding techniques and quantitative performance evaluation. *Journal of Electronic Imaging.* 13(1) : 146-165.

Shapiro, V., Dimov, D., Bonchev, S., Velichkov, V. and Gluhchev, G. (2003). Adaptive Licence Plate Image Extraction. *International Conference on Computer Systems and Technologies – Compsystech'2003.*

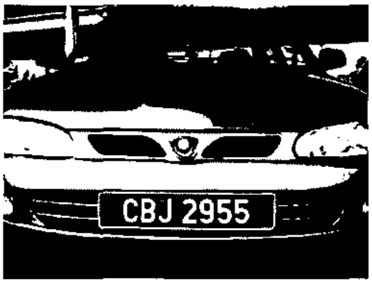
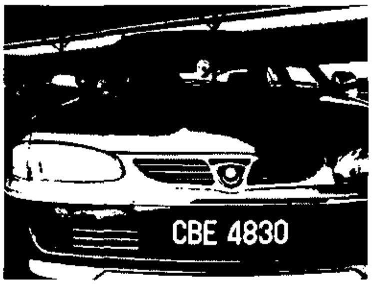
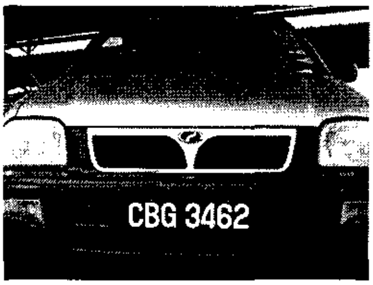
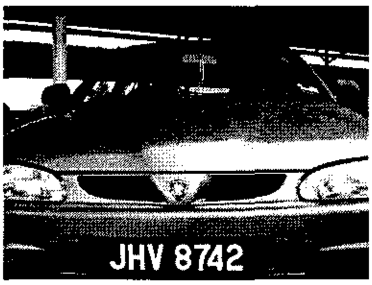
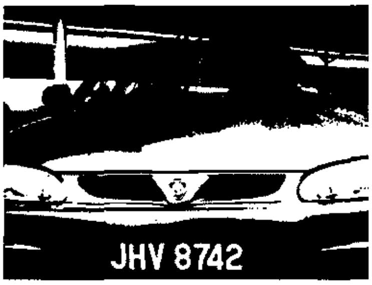
Umbaugh, S. E. (1998). *Computer Vision and Image Processing : A Practical Approach Using Cviptools.* Prentice Hall International.

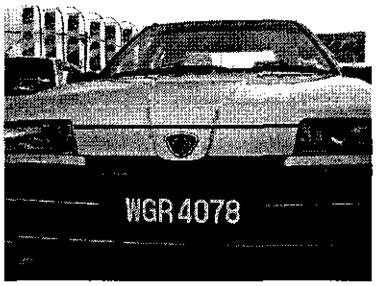
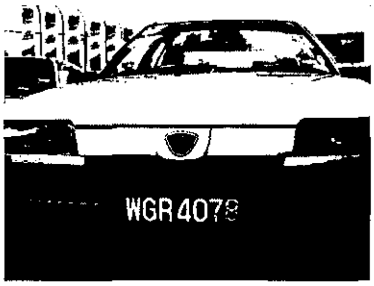
Yakoub, B. (2001).*A Comparative Study of Histogram Based Thresholding Algorithms.* University of Trento.

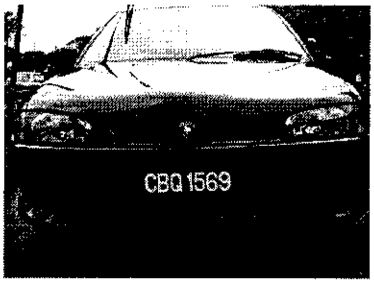
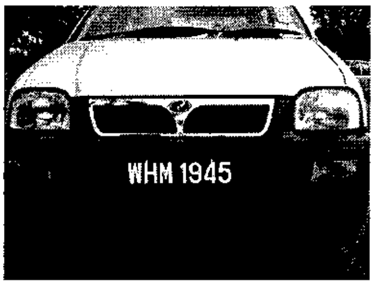
Zalili Binti Musa (2002). *Sistem Pengesanan Kerosakan Pada Jalinan Tekstil.* Universiti Teknologi Malaysia: Masters. Thesis.

APPENDIX A

SAMPLE CAR PLATE IMAGES AND RESULTS

Original Image	Result of Threshold I	Result of Plate Detection
		
		
		
		
		

Original Image	Result of Threshold I	Result of Plate Detection
		
		N / A
		
		
		

Original Image	Result of Threshold I	Result of Plate Detection
		
		
		
		
		

Original Image	Result of Threshold I	Result of Plate Detection
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	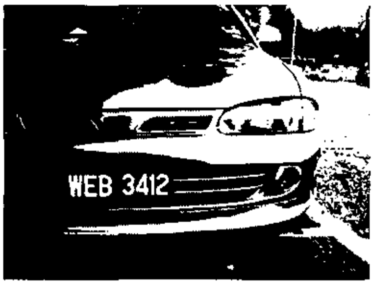	
		
		
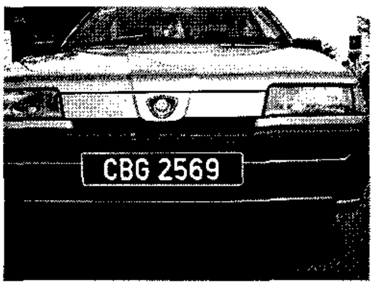		

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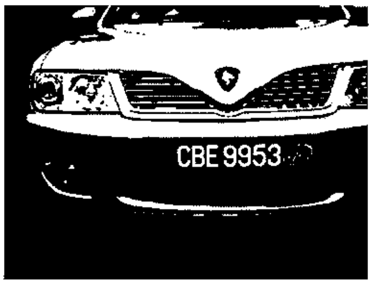
</td><td>
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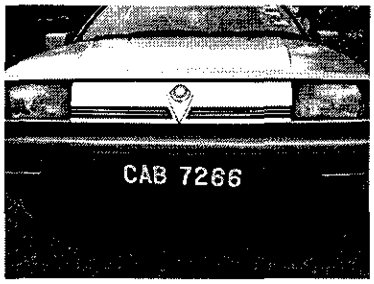
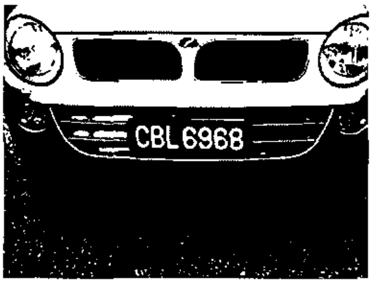
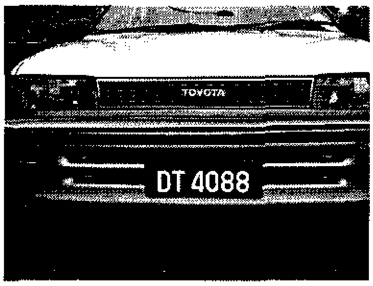
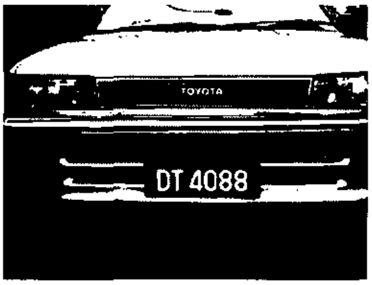
		
		N / A
		
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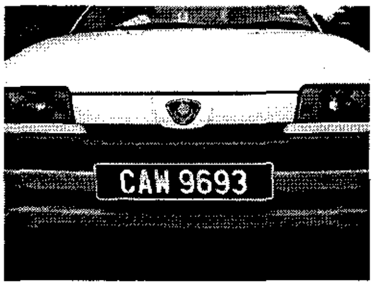
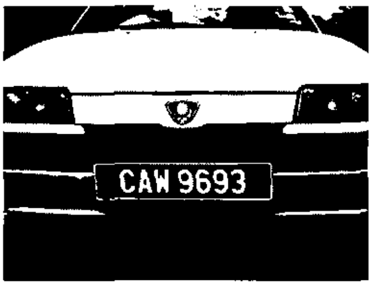
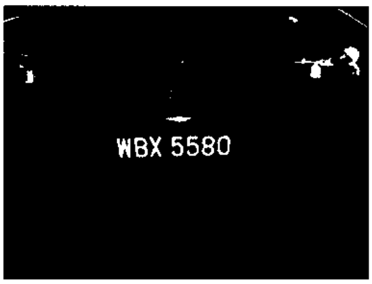
		

Original Image	Result of Threshold I	Result of Plate Detection
		
		
		
		
		

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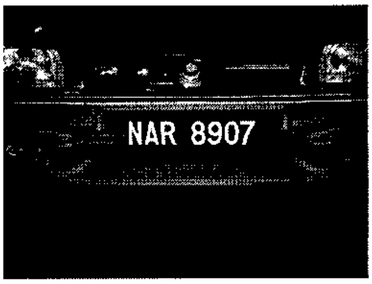
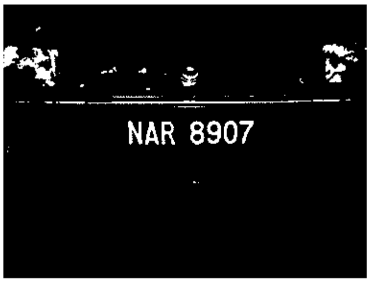
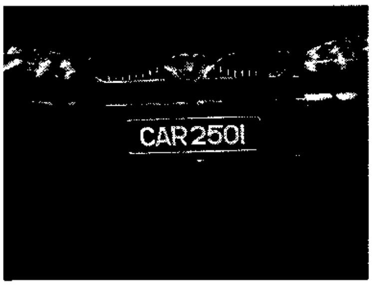
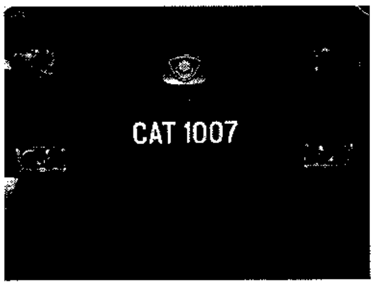
		
		N / A
		
		
		

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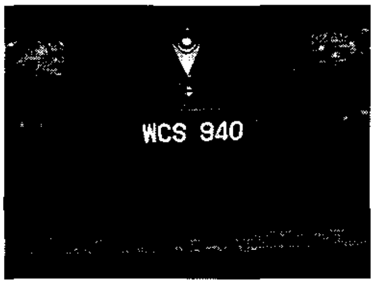		
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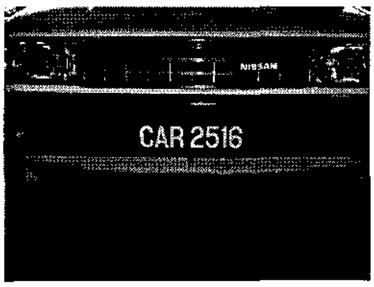
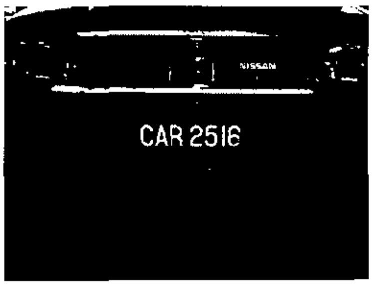
		N / A
		

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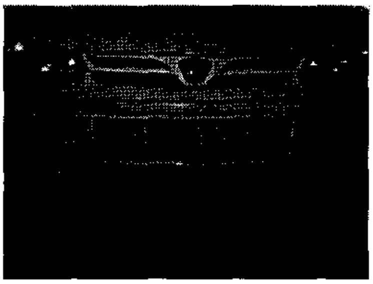
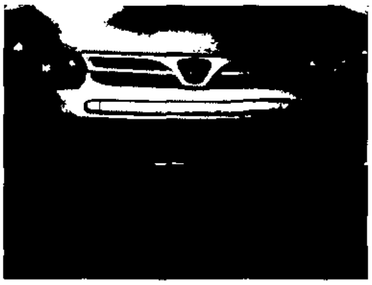
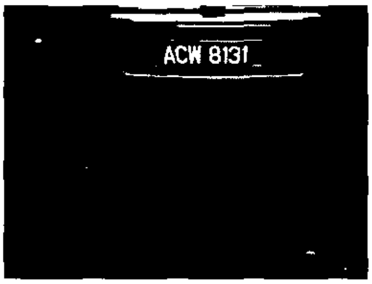
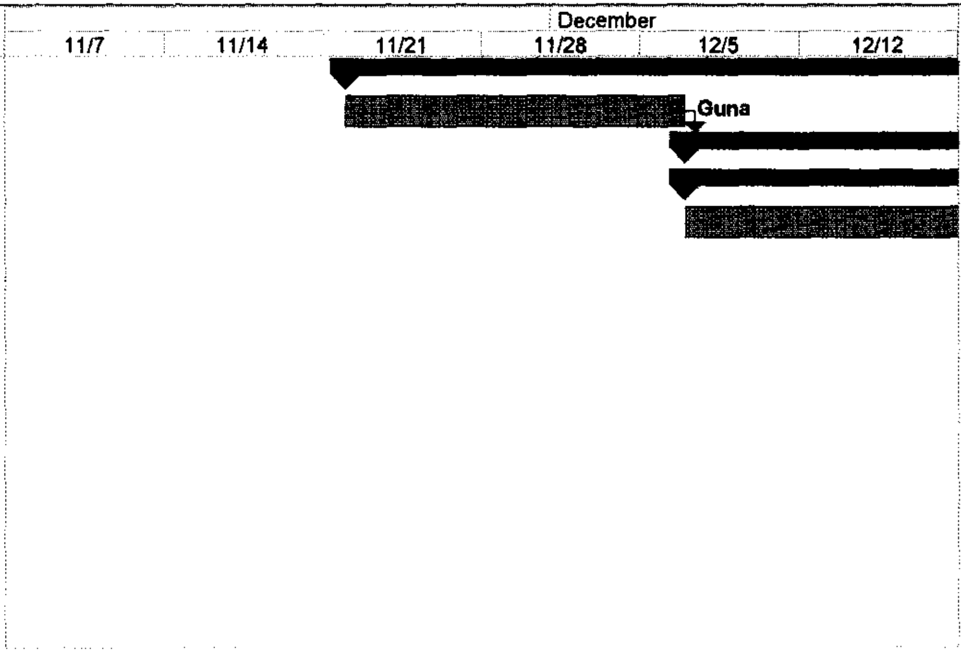
		N / A
		

APPENDIX B

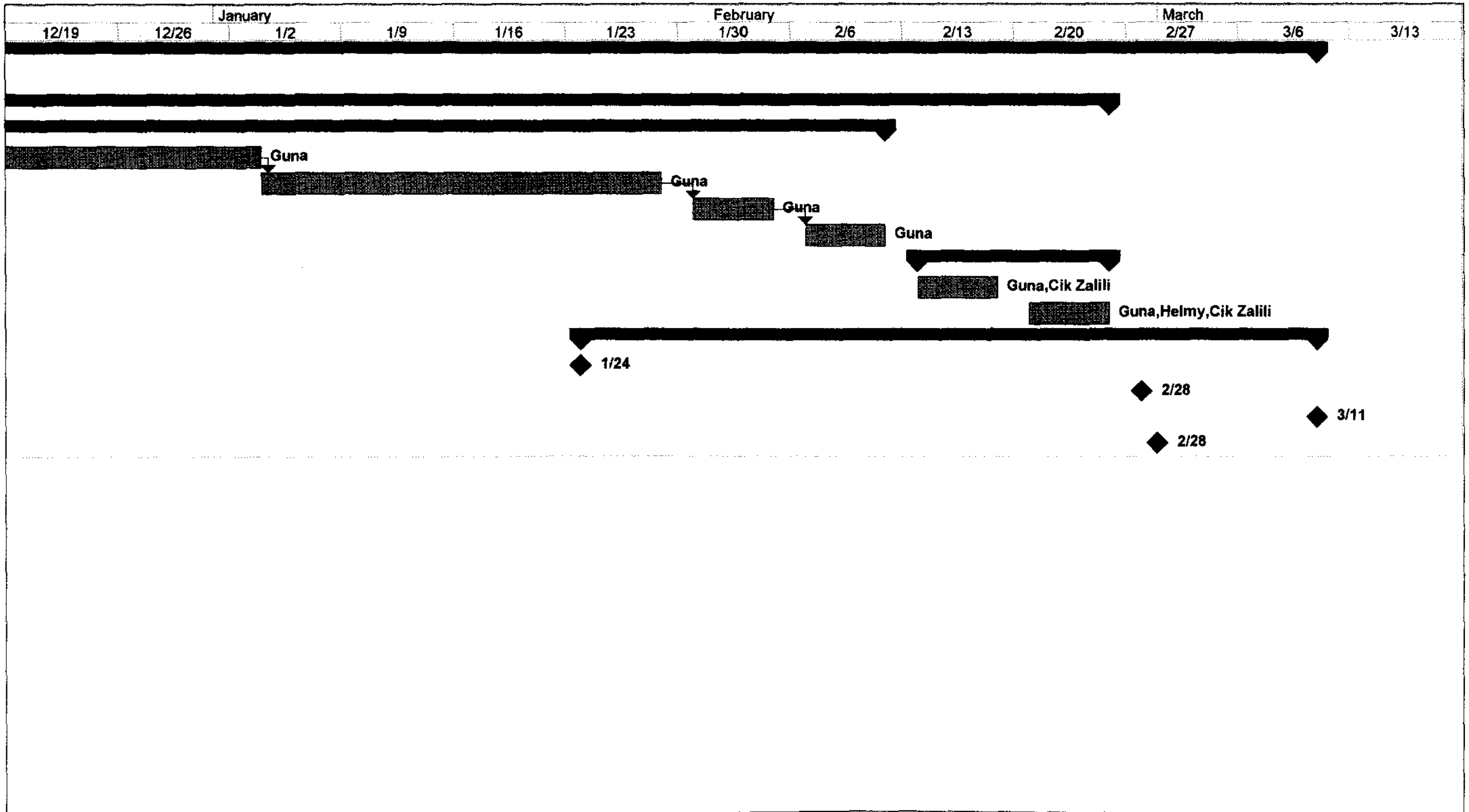
GANTT CHART

ID	Task Name	Duration	Start	Finish
1	**CARPROS**	**79 days**	**Mon 11/22/04**	**Fri 3/11/05**
2	Proposal	11 days	Mon 11/22/04	Mon 12/6/04
3	**Software Development**	**59 days**	**Tue 12/7/04**	**Fri 2/25/05**
4	**Image Processing**	**49 days**	**Tue 12/7/04**	**Fri 2/11/05**
5	Image Acquisition and Filtering	20 days	Tue 12/7/04	Mon 1/3/05
6	Image Thresholding	19 days	Tue 1/4/05	Fri 1/28/05
7	Image Thinning	5 days	Mon 1/31/05	Fri 2/4/05
8	Image Segmentation	5 days	Mon 2/7/05	Fri 2/11/05
9	**Testing Phase**	**10 days**	**Mon 2/14/05**	**Fri 2/25/05**
10	Unit Testing	5 days	Mon 2/14/05	Fri 2/18/05
11	Integration Testing	5 days	Mon 2/21/05	Fri 2/25/05
12	**Deliverables**	**34 days**	**Mon 1/24/05**	**Fri 3/11/05**
13	Presentation on Proposal Progress	0 days	Mon 1/24/05	Mon 1/24/05
14	PSM Presentation	0 days	Mon 2/28/05	Mon 2/28/05
15	Correction & Final PSM Submission	0 days	Fri 3/11/05	Fri 3/11/05
16	**End of Project**	0 days	Mon 2/28/05	Mon 2/28/05



Project: PSM Gantt Chart Ver 1.1
Date: Wed 3/23/05

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline



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