AUTOMATIC NUMBER PLATE RECOGNITION BY USING MATLAB

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By

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Table of Content

List of Table

List of Figures

List of Abbreviations

ALPR	Automatic License Plate Reader
ANN	Artificial Neural Network
ANPR	Automatic Number Plate Recognition
BLE	Bluetooth Low Energy
CPR	Car Plate Recognition
HIS	Hue Intensity Saturation
HT	Hough Transform
ITS	Intelligent Transportation System
LPR	License Plate Recognition
MLPR	Mobile License Plate Reader
NPT	Number Plate Tracking
RGB	Red Green Blue
ROI	Region of Interest
SCW	Sliding Concentric Window

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ABSTRACT

Usually, surveillance system is used for security purposes and monitoring systems. This surveillance system is also used for home security, traffic monitoring and at ATM security. Human activity detection and tracking has increased in usage due to decreasing cost of video surveillance camera. Moreover, automated systems had been designed for numerous detection tasks, but the task of detecting illegally parked vehicles has been left for human operators of surveillance system. Automatic Number Plate Recognition (ANPR) system is an image processing technology that identifies the vehicle by tracking its number plate without direct human involvement and it is widely used in Intelligent Transportation System (ITS). In this project, extraction and recognition of vehicle number plate from an image is done by using MATLAB. The image of the vehicle is captured by using camera and the image is sent to MATLAB by using Raspberry Pi 3. Besides, this project presents an approach based on morphological operation and Sobel edge detection method. Then, the approach is simplified to segmentation of all the characters in the number plate by using bounding box method. The segmented character on the plate has been extracted and recognized by using template images of alphanumeric character. Furthermore, new algorithm in MATLAB has been used to extract the vehicle number plate in various luminance condition. The system able to detect vehicle number plate at 95% success rate.

PENGESAN NOMBOR KENDARAAN SECARA AUTOMATIK DENGAN MENGGUNAKAN MATLAB

ABSTRAK

Lazimnya, sistem pengawasan digunakan untuk sistem pemantauan dan sistem keselamatan. Sistem pengawasan ini digunakan untuk keselamatan rumah, pemantauan lalu lintas dan keselamatan ATM. Pengesanan dan pengesanan aktiviti manusia meningkat secara praktikal kerana penurunan dalam kos kamera pengawasan video. Selain itu, sistem automatik telah direka untuk pelbagai tugas pengesanan, tetapi tugas mengesan kenderaan yang diletak secara haram telah diserahkan untuk pengendali sistem pengawasan yang menggunakan tenaga manusia. Sistem Pengesan Nombor Kenderaan Secara Automatik (ANPR) adalah teknologi pemprosesan imej yang mengenal pasti kenderaan dengan mengesan nombor pendaftaran kereta tanpa penglibatan manusia secara langsung dan ia digunakan secara meluas dalam Sistem Pengangkutan Pintar (ITS). Dalam projek ini, pengekstrakan dan pengesanan nombor kenderaan daripada gambar dilakukan dengan menggunakan MATLAB. Gambar kenderaan diambil dengan menggunakan kamera dan gambar tersebut dihantar ke MATLAB dengan menggunakan Raspberry Pi 3. Selain itu, projek ini membentangkan pendekatan berdasarkan operasi morfologi dan kaedah pengesanan Sobel. Kemudian, pendekatan itu dipermudahkan dengan membahagikan semua aksara dalam plat nombor dengan menggunakan kaedah kotak terikat. Watak bersegmen pada plat telah diekstrak dan dikesan dengan menggunakan imej template watak abjad dan angka. Selain itu, algoritma baru dalam MATLAB telah digunakan untuk mengesan nombor pendaftaran kenderaan dalam pelbagai keadaan pencahayaan. Sistem ini dapat mengesan plat nombor kenderaan pada kadar kejayaan 95%.

CHAPTER 1

Introduction

1.1 Background

A number plates is attached to vehicle for identity purposes and it is a legal necessity that applies to vehicles in most countries. It gives a unique identity to a vehicle, which can be used to trace the vehicle owner through a database which is linked to the record of information, such as owner details and vehicle details. All license plates must be registered with the owner's name, address, and registered number under the world's first license plate rule which is applied in France on 14 August 1983.

Currently, a license plate can be used to avoid traffic violations such as car theft, running the red light and over speed. However, due to the increasing number of vehicle from year to year, it is not possible to manually keep record of entire vehicle and traffic violations are appearing more frequently. Although, many of surveillance cameras are installed at places such as parking booths, toll booths, gated and guarded community areas and traffic lights, they require man-power to check their images and note down the vehicle registration number so that it can be sent to appropriate department to take rule violators action. To overcome this problem, the Automatic Number Plate Recognition (ANPR) was invented. This ANPR is also known as License Plate Recognition (LPR), Car Plate Recognition (CPR), Mobile License Plate Reader (MLPR), Automatic License Plate Reader (ALPR) and Number Plate Tracking (NPT) [1, 2].

Automatic Number Plate Recognition (ANPR) is a system which aids human to detect car number plate. Besides, ANPR is an image processing technology that able to automatically identify the vehicle by extracting car number plate characters from an

image without direct human involvement. This system is able to extract and recognize the car number plate characters from stationary camera monitoring system and mobile monitoring system. It is an easier method for vehicle identification. Mechanically, ANPR is beneficial for many businesses and organizations for a wide variety of applications including vehicle parking lot management, highway ticketing, electronic toll collection and security applications such as access control to restricted areas and tracking of wanted vehicles [3].

Besides, ANPR can be used as a form of security at campus and gated communities through automatic opening of the gate only to authorized vehicles. ANPR will recognize the car number plate automatically and compare the number with the numbers in the database. If that specific plate number is in the database, then the gate lifts up and the car will be allowed to enter the property. This can help save man power as the security guards do not have to open and close the gate manually.

Moreover, ANPR can also be used as parking management system at parking garages and parking lots [4] as shown in Figure 2.1. It can improve traffic flow during peak periods and manage information about car park usage. ANPR also can help user to relocate their vehicle in a large parking lot by detecting the location of the vehicle after the car plate number is inserted by users.

Figure 2.1: ANPR Parking System

ANPR had been developed for many years and its accuracy had been improved with the implementation of new hardware and software. However, the current accuracy is not able to satisfy all the requirements in various fields. Successful implementations of ANPR system will make the vehicle identification process becomes faster and easier.

1.2 Problem Statement

Many years ago, private car was a deluxe device and it will only be used by a few people. Time consciousness in the modern day has made the car a basic need in human life. Therefore, the number of car owners is increasing every day because every person expects the freedom to travel and comfort while travelling. They travel from one place to another for a great variety of reasons. Most family in developed countries own at least a car and this situation is not much different in developing countries either. However, owning a car has some disadvantages as well. The main disadvantage of owning a car is difficulties to find a parking spot.

In Malaysia, most of the parking management at parking lots are using conventional car park ticketing system which requires human effort to keep the parking ticket safely and pay at autopay station. However, the problem will arise in this conventional car park system when the user had misplaced or accidently lost the parking ticket. The user will be charged a higher rate as they could not verify the duration they used the car park. Besides, the low quality of the parking ticket will cause difficulties to autopay machine system to calculate the amount of fee for the parking service. This conventional car park ticketing system also might cause damage to the car as the user has to drive their car close to the parking ticket kiosk for them to reach out their hand to the kiosk and take the parking ticket.

Furthermore, the gated community usually use membership sticker which will be attached on the windscreen of the vehicle to enable the car driver to get access to the place. Thus, the security guard must be hired for them to check each vehicle one by one and confirm the membership details by checking the membership sticker on the windscreen of the vehicle or by checking the driver's identification card before giving permission to enter the gated area. The security guard must record the vehicle details such as vehicle number plate onto an occurrence book which might cause in loss of data because the data is stored in hardcopy and difficult to backup.

By employing automatic number plate recognition system in car park management and gated community security control, conventional car park ticketing system and human control security can be replaced. However, current ANPR system has its own disadvantages as the vehicle image must be captured from a fixed distance [5]. The current ANPR system also faces major problem when detecting vehicle license plate with different length of license plate [6].

1.3 Objectives

1. To develop an automatic number plate recognition system by using MATLAB.
2. To develop a system that able to recognise vehicle license plate with different distance of vehicle licence plate from camera and identify the unregistered vehicle.
3. To create a device hardware capable of capturing pictures and sending the data via a Wi-Fi network to a server.

1.4 Project Scope

For this project, the proposed system serves as an improvement and alternative to the car identification and current car park management system. The scope of the project is to develop an algorithm to identify the characters from vehicle license plates by using MATLAB software. The mechanisms of this project consist of personal computer to integrate all the software and Raspberry Pi Noir camera board v2 to capture the real time image into personal computer for license plate recognition process. In practice, the system must be able to reduce human effort in managing the increasing number of car.

1.5 Thesis Organization

This thesis is split into five chapters, each of which containing important descriptions of this project. Various progressions and parts of this project are described in these chapters, and in reading this thesis, a more in-depth understanding of image processing for car plate number recognition will be acquired. This thesis is structured as follows:

Chapter 1: An introduction to the build of this project, which includes the Background, Problem Statement, Objectives and Project Scope.

Chapter 2: An exhaustive literature review of this study is presented, where it summarizes the recent researches and scholarly sources relevant on the particular issues and theories in this project.

Chapter 3: This chapter is dedicated to the Methodology of this build, where the process flow in developing this system is thoroughly described. The architecture of the system, both hardware and software in its entirety is illustrated and explained in this chapter.

Chapter 4: Here the various experiments and tests that are conducted throughout the development of this system are presented and discussed. In addition, the obtained results or performance are presented and discussed in detail.

Chapter 5: The conclusion and the highlight in the development of the system is put forth in this chapter, following which a couple of interesting directions to be undertaken and pursued are detailed here as well as future implementation.

CHAPTER 2

Literature Review

2.1 Introduction

In general, ANPR systems are divided into four steps, namely input image capture, number plate detection, character segmentation and character recognition. The accuracy of number plate recognition mainly depends on the quality of input image capture. The input image which has low quality and does not have component of vehicle number plate might cause the system to detect the number plate wrongly and this will be one of the major issues that will lead to an inaccurate result. This chapter will focus more on the literature survey on vehicle number plate detection. This chapter starts off with the introduction about the MATLAB software in section 2.1. Section 2.2 investigates the image segmentation techniques to detect vehicle number plate, while Section 2.3 goes into the character segmentation method. The character recognition methods which is used to detect vehicle plate number are explained in Section 2.4. The final portion of this literature review which is Section 2.5 concludes this chapter.

2.1.1 MATLAB

MATLAB is a data analysis and visualization tool which has been designed with powerful support for matrices and matrix operations that has excellent graphics capabilities and powerful programming language. MATLAB programs which are known as toolboxes are designed to support a task such as investigating images and their properties which will be supported by image processing toolbox and image acquisition toolbox. A MATLAB function such as *sin*, *imread*, and *imclose* is a keyword which accepts various parameters and produces output in the form of a graph, a string, a matrix or a figure. MATLAB's standard data type is the matrix and all the data are matrices. For example, images are matrices whose elements are the grey values or RGB values of

pixels. Single values are considered by MATLAB to be 1 x 1 matrix, while a string is merely a *1 x n* matrix of characters where *n* is the string's length.

2.2 Number Plate Detection

Number plate detection is a process to locate the vehicle number plate which will help the ANPR system for faster character identification over a smaller region. To detect the vehicle number plate, factors such as number plate size and number plate location must be considered as the vehicle number plate can be of different sizes in different input images and the number plate can be located anywhere in the vehicle. The vehicle number plate can be detected by using image segmentation method and there are various image segmentation methods that can be applied. In the following sections, common vehicle number plate detection methods are explained, and it is followed by detailed discussion of image segmentation techniques implemented in various literatures.

2.2.1 Grayscaling Process

Grayscaling is a process of converting a multicolor image to a gray scale image by calculating the threshold value of the image. A correct threshold value is important to provide sufficient contrast to differentiate foreground and background in an image [2].

2.2.2 Image Binarization

Binarization is a process of converting a pixel image to a binary image and it will produce black and white image from a grayscale image. In this method, threshold must be set to classify black pixels and white pixels. The threshold can either be set fixed or adaptive using a clustering algorithm which is called Iso Data Algorithm [5]. This

algorithm will first count the appearance of each tone in the image and tries to find a good center.

2.2.3 Edge detection

Edge detection technique is a mathematical method that identifies the boundaries of objects in an image. It is a basic method for image segmentation and data extraction. Different edge detection algorithms such as Sobel, Canny, Prewitt, Canny-Deriche, Differential, and Roberts Cross can be used for edge detection [7].

2.2.4 Morphology

Morphology is a set of image processing operations that are useful in the shape representation and extraction of geometrical structure. Morphology is well suited for binary image processing that is used to detect boundaries of object. The most basic morphological operations are dilation and erosion. Dilation will cause object to grow as it adds pixels to the boundaries of object in an image while erosion will cause the size of object to decrease as it removes pixels on object boundaries [5].

2.2.5 Other methods

Image binarization, edge detection and morphology are basic methods for plate identification. Aside from these techniques, various researches discussed about various techniques for plate detection. Anagnostopoulos et al. [7] proposed sliding concentric window (SCW) technique that consists of two steps method containing two concentric windows moving from upper left corner of image which calculate the statistical measurement in both windows based on segmentation rule that says the central pixel of the windows is considered belong to region of interest (ROI) if the ratio of the median or

mean in the two windows exceeds a threshold that had been set based on try and error basis. Chen et al. [8] proposed a feature silent method to extract vehicle number plate by using features such as texture, shape, and colour. Hough transform (HT) was used to detect horizontal and vertical line from vehicle number plate. Then, red, green, blue (RGB) is converted to hue-intensity-saturation (HIS) before number plate is segmented. Lakshmi et al. [9] proposed a novel approach for Indian License Recognition System which is based on wavelets and texture characteristics. Morphology operation was also used for better performance.

2.3 Character Segmentation

Character segmentation is the step that acts as a bridge between the number plate detection and character recognition. In this phase, the area that contains characters are extracted one by one from the number plate [10].

2.3.1 Split and merge methods

Split and merge is also known as quadtree segmentation where it is based on quadtree partition and the data structure used is called quadtree. It divides regions that do not pass the homogeneity test and combine regions that pass the homogeneity test [5].

2.3.2 Other methods

In some algorithms, character segmentation is done by using region-based image segmentation technique to classify a particular image into several regions according to the ordinary characteristic of the image [8]. In this technique, the regions are grouped to ensure the pixels in the region have the similar value of the properties such as pattern and texture, spectral profile of the image, and the intensity values. Pan et al. [10] proposed an

improved projection method by mentioning three-step procedures for character segmentation which start with correction of vertical, horizontal and compound tilts. Then, to detect connected boundaries, lines are drawn in between first and last characters before the characters are segmented after removing noise. Ozturk and Ozen [11] used vertical and horizontal histogram method to determine the boundaries of character by using column sum vectors. Two adjacent characters are separated in two based on the algorithm.

2.4 Character recognition

Character recognition is the last stage in ANPR that identifies and converts segmented character from an image into editable text. Character recognition has been a complication in the field of image processing, as there is high probability that the character produced from the normalization step varies from the database in terms of shape, size and style that could result in inaccuracy in character recognition and affect the usefulness of the whole system. Character recognition is the most important task in recognizing the number plate and the system must be able to differentiate the character correctly as sometimes the system may be complicated due to the similarities in the form of shape as the characters consist of numbers and letters. In this section, each method that is used to identify character using the features extraction is explained.

2.4.1 Template matching

Template matching has been used widely in face detection, medical image processing and ANPR. The recognition of the segmented character in ANPR is done by calculating the correlation coefficient where the template character that scores the highest correlation is selected as the character of the segmented character from an image. The size of the segmented character image and the template character must be the same [12]. Recently, Puranic et al. [13] proposed the development of automatic vehicle plate

detection system by utilising template matching concept which calculates the correlation coefficient and the template character that scored the highest correlation will be selected as the character of the input segmented character.

2.4.2 Other methods

In some algorithms, character recognition is done by using k-nearest neighbour (KNN) which the technique recognised the character based on least difference between the segmented character and the template character. Soon et al. [14] used KNN to classify the characters for recognition purpose. In this approach, every character class must train the KNN classifier by using training samples which will be extracted as feature vectors for the classifier. However, character similarities such as “5” and “6”, “1” and “7” might cause inaccuracy in recognition. Bedruz et al.[15] used Fuzzy Image Processing for text detection and character recognition. This system has a short processing time and high accuracy but it is sensitive to distortion and noise. More recently, Maghsoudi et al. [16] proposed Artificial Neural Network(ANN) technique in automatic car plate detection and recognition system. ANN provides good accuracy in recognition, but it requires periodic training for better accuracy and it has longer processing time.

2.5 Summary

In summary, the current and basic knowledge on vehicle number plate detection and its approaches were studied in this chapter. The general understanding on MATLAB software were explored as well. The proposed project aims to develop an ANPR using the knowledge obtained in this literature review. Moreover, the limitation of the current ANPR system were identified which the vehicle image must be captured from a fixed angle and fixed distance.

Chapter 3

Methodology

3.1 Introduction

As mentioned in the previous chapter, the idea is to build a device capable of detecting vehicle number plate automatically. Attached to this project are two major components, that are hardware development and software development. The device is made up of Raspberry Pi 3 Model B which captures image using Pi Noir Camera V2. This image is then sent over via a Wi-Fi network to MATLAB software. The MATLAB software will detect car number plate automatically by using image processing toolbox. Figure 3.1 shows the build flowchart with a detailed breakdown of the development of individual components such as the software development and hardware development whereas Figure 3.2 illustrates a basic breakdown of the entire system architecture for ANPR. The hardware development will be detailed in Section 3.2, while the system architecture development will be explained in Section 3.3.

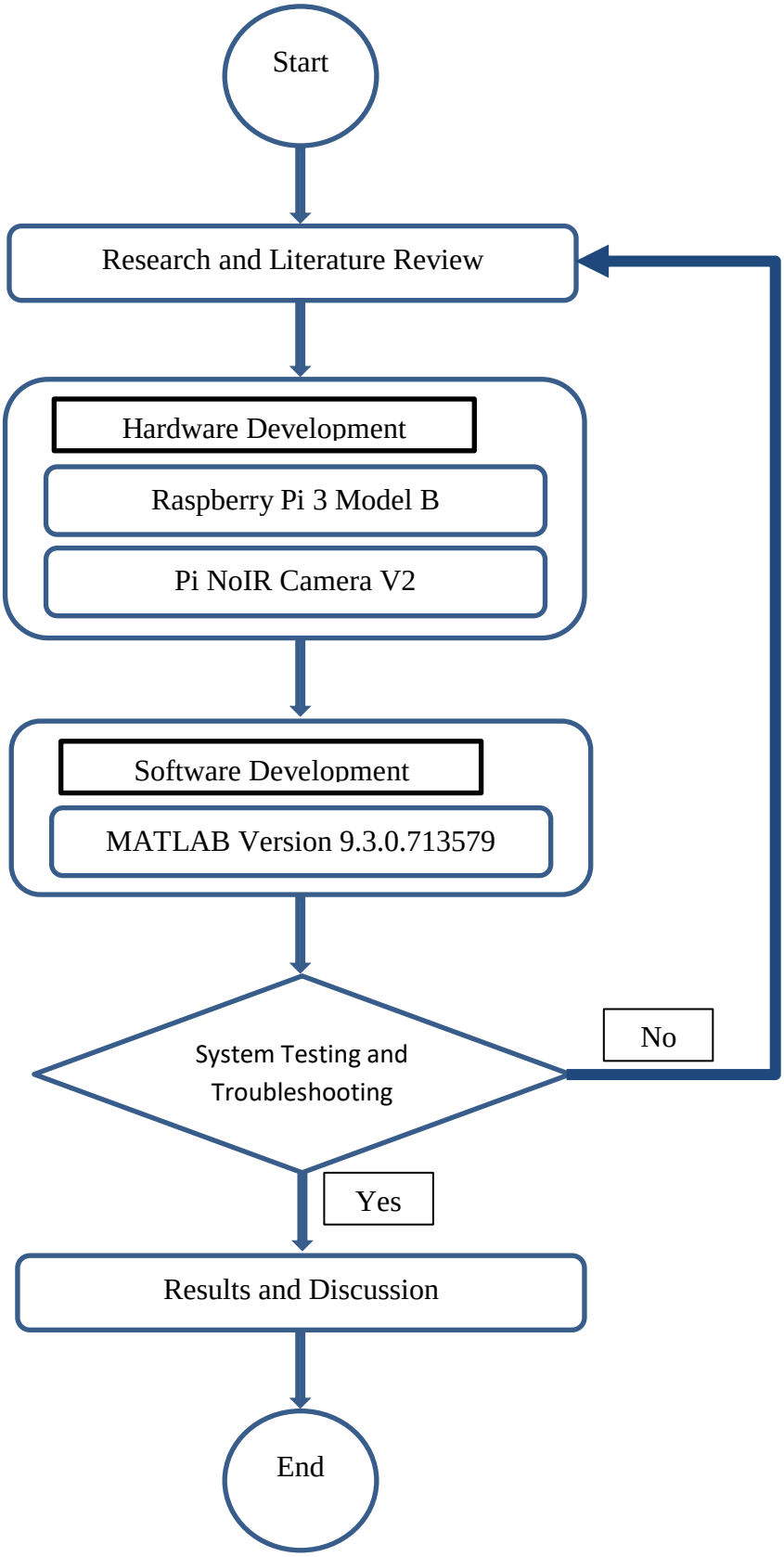


Figure 3.1: Build implementation flow chart

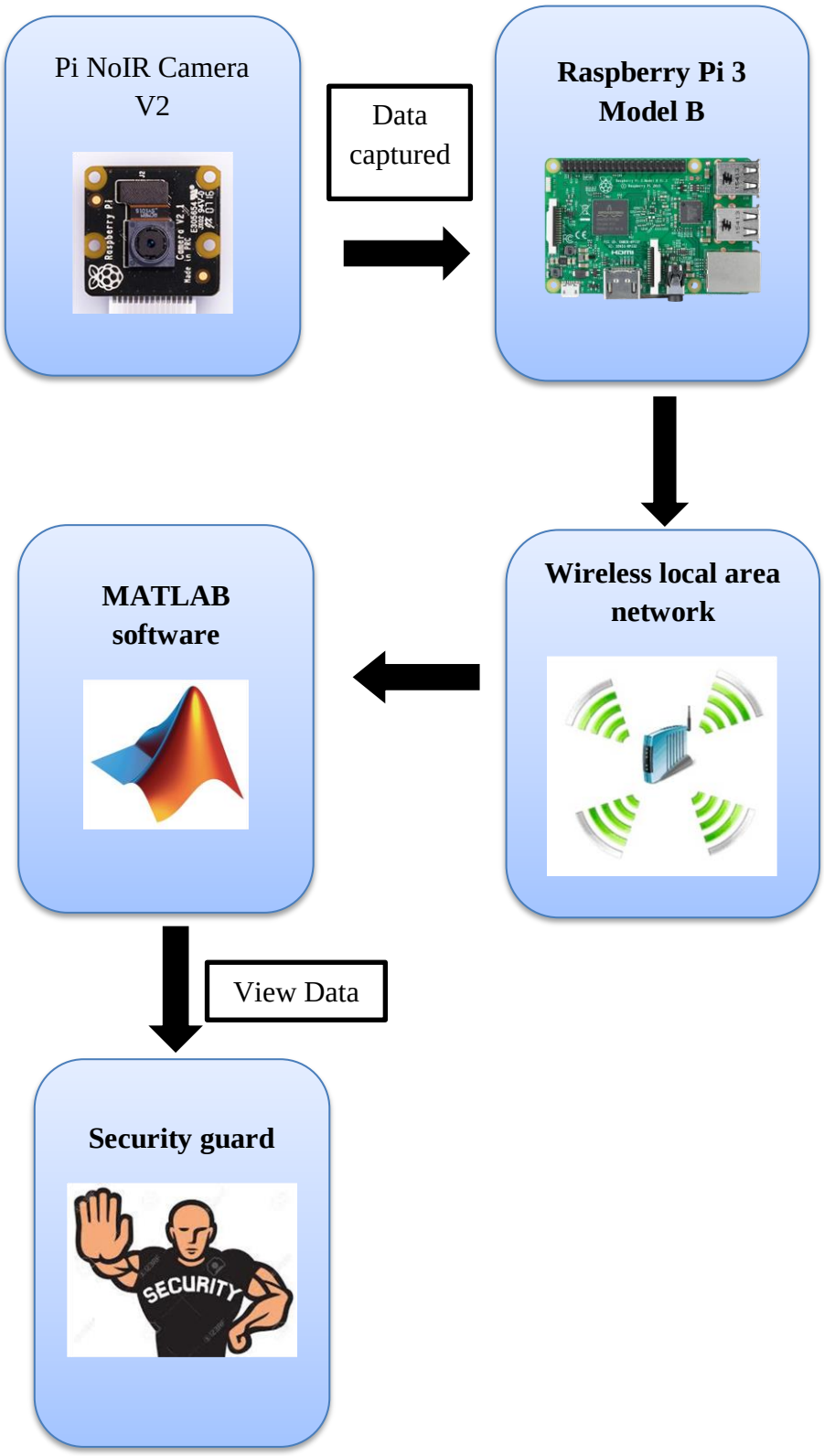


Figure 3.2: System Architecture

3.2 Hardware development

Automatic Number Plate Recognition system consists of hardware such as camera, controller board and a computer. In this project, Pi NoIR Camera V2 is used in the image acquisition stage. It is primarily used to capture the image of vehicles. Figure 3.3 shows the camera used in this build.

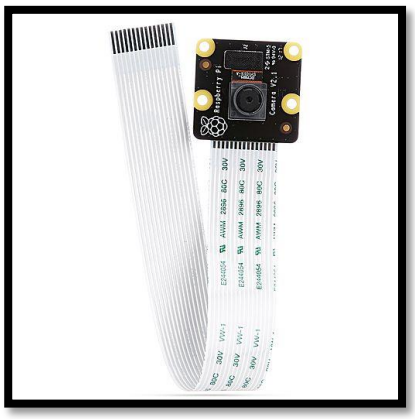


Figure 3.3: Pi NoIR Camera V2

Besides that, Raspberry Pi 3 Model B is used as the controller board for this project as shown in Figure 3.4. This controller board is used to send the captured image via Wi-Fi network to the computer that had been installed with MATLAB software. Table 3.1 shows the hardware specifications used in this ANPR system.

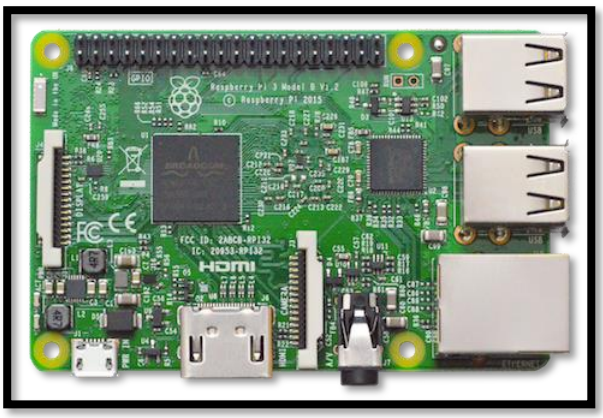


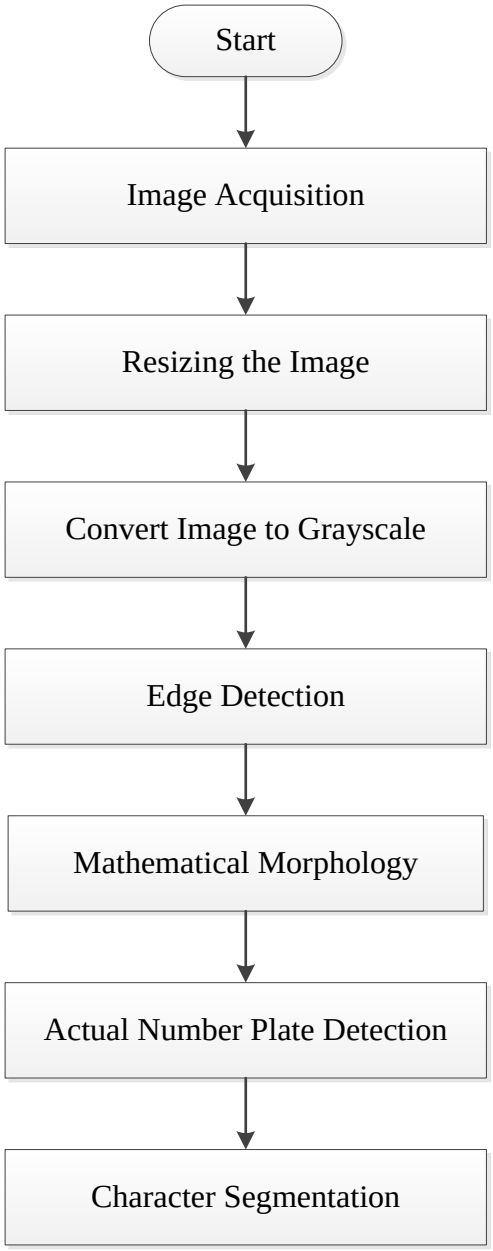
Figure 3.4: Raspberry Pi 3 Model B

Table 3.1: Hardware specification

Hardware	Specification
Pi NoIR Camera V2	Weight: 3g
	Still resolution: 8 Megapixels
	Video Modes: 1080p30, 720p60 and 640 x 480p60/90
	Sensor: Sony IMX219
	Sensor resolution: 3280 x 2464 pixels
	Sensor image area: 3.68 x 2.76mm
	Pixel size: 1.12µm x 1.12µm
Raspberry Pi 3 Model B	Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
	1GB RAM
	BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
Asus Laptop	Processor: Intel Core i7-3610QM CPU @ 2.30GHz
	RAM: 8.00GB
	System Type: 64-bit operating system
	Operating System: Windows 10

3.3 Software Development

Automatic Number Plate Recognition system uses MATLAB software Version 9.3.0.713579 or R2017b to recognize vehicle plate number automatically. This MATLAB software is installed in Windows 10 operating system. Figure 3.5 shows the flowchart diagram of the steps done by the MATLAB software to recognize vehicle plate number automatically. The details of each step are to follow in the following sections. The MATLAB code is provided in Appendix A.



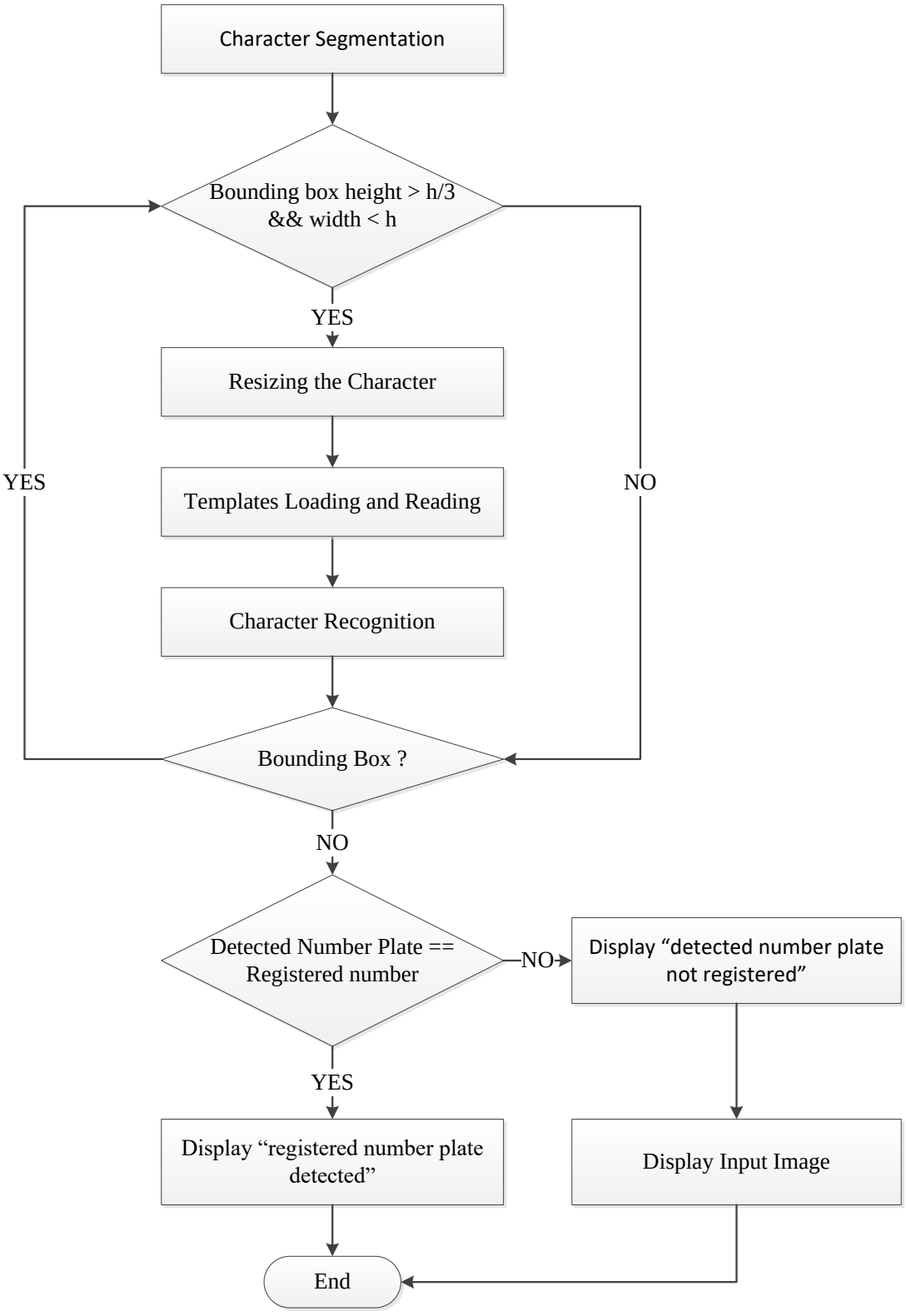


Figure 3.5: Flow chart

3.3.1 Image Acquisition

Image Acquisition is the process of obtaining an image from the digital camera. Images are taken at various distances in different backgrounds and illuminations. Different types of images such as bright image, dark image and blurred image can be acquired during camera capturing. Figure 3.6 shows the input image of a vehicle image. This vehicle image can be captured by using image acquisition toolbox which can help MATLAB to get image and video directly from the camera. Besides that, MATLAB can detect the hardware and configure the hardware properties automatically. Figure 3.7 shows the screenshot of the camera configuration that has been detected by MATLAB automatically and this camera properties can be altered easily.

Figure 3.6: Input Image

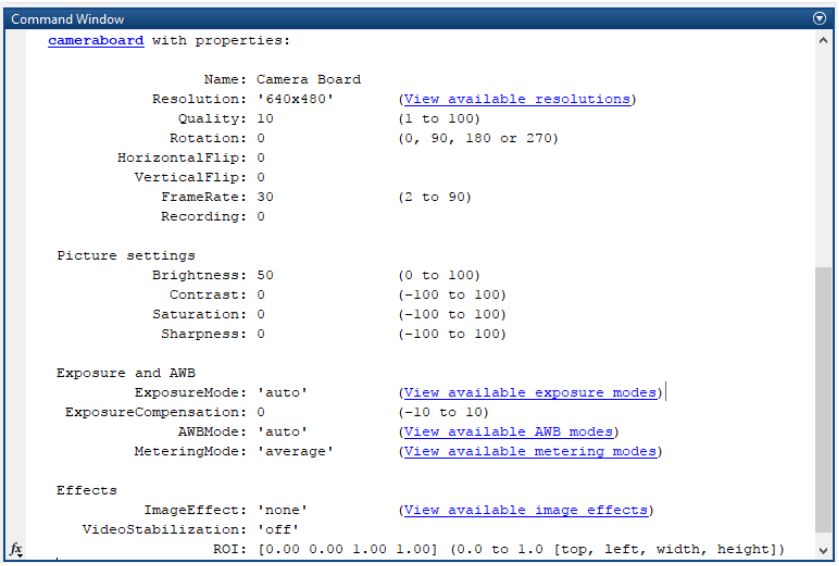


Figure 3.7: Camera Configuration

3.3.2 Preprocessing

The preprocessing is used to improve the input image and make it suitable for vehicle number plate recognition. Preprocessing will enhance the image by removing the background noise, removing image reflection, image debluring and normalizing the intensity of individual image particles. The preprocessing for vehicle license plate number is done in several methods.

3.3.2.1 Resizing the Image

After the image is acquired, the image is resized to 480 x NaN resolution. In this resolution, the RGB image will resize to have 480 rows and the number of columns is calculated automatically. The resizing is used to resize an image and make the input images size become more constant which will allow the system to perform operation in a more effective manner by decreasing its computational time. *imresize* function is used to resize an image in MATLAB. Figure 3.8 shows the input and output image that is resized using resized function in MATLAB.

Input Image Output image

Figure 3.8: Output of resize function

3.3.2.2 Convert Image to Grayscale

The captured input image is converted from RGB image to gray scale image. This conversion is done by using *rgb2gray* function in MATLAB. Figure 3.9 shows the gray scale image. The RGB image is converted to gray scale by eliminating the saturation information while retaining the luminance. This is done by converting RGB values to gray scale value by forming a weighted sum of the R, G and B components.

Figure 3.9: Gray Scale Image

3.3.3 License Plate Detection

License plate detection identifies specific features that contain the vehicle number plate in an input image. The vehicle number plate can be found anywhere within an image and it is impractical to check all the pixels of the image in order to locate the vehicle number plate. Therefore, the license plate detection can help ANPR system to only focus on those pixels that have number plate. License plate detection can be categorized into four subsections which are edge detection, mathematical morphology, actual number plate detection and extracted number plate region enhancement. A brief explanation of these subparts is as following subsections.

3.3.3.1 Edge detection

Edge detection using Sobel method is done on binary image in order to identify the boundaries of character that are not broken as the edges. This edge detection is a set of mathematical methods that identify points in digital image at which the brightness changes sharply and has discontinuities. The point at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. Figure 3.10 shows the results of applying Sobel operator to binarized image. Edge detection is used to distinguish the edge in picture to localize the position of vehicle number plate. After experimenting with different types of edge detection method which consist of Sobel, Prewitt and Canny; Sobel edge detection method was chosen as it provides the fastest processing time.