



Faculty of Electrical and Electronic Engineering Technology



**NUMBER PLATE RECOGNITION SYSTEM BASED ON SOBEL
EDGE DETECTION, BOUNDING BOX AND TEMPLATE
MATCHING**

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Bachelor of Computer Engineering Technology (Computer Systems) with Honours

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**NUMBER PLATE RECOGNITION SYSTEM BASED ON SOBEL EDGE
DETECTION, BOUNDING BOX AND TEMPLATE MATCHING**

MUHAMMAD AMIRUL FAIZ BIN MOHD REDWAN

**A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours**



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA
Faculty of Electrical and Electronic Engineering Technology**

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DECLARATION

I declare that this project report entitled “NUMBER PLATE RECOGNITION SYSTEM BASED ON SOBEL EDGE DETECTION, BOUNDING BOX AND TEMPLATE MATCHING” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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11/1/2022



APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer

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Name (if any)

Date :



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DEDICATION

To my lovely mum and dad,

Mohd Redwan Bin Abd Rahman and Nor Aidah Binti Deraman,

With loving sacrifices and their unconditional support in my life,

To my siblings and friends,

Who always who always help me prepared and completed this report.

And

For those I love very much

For the lectures, my supervisors, assistant engineers who are given

much guidance to me without expecting any reward



ABSTRACT

Number Plate Recognition became a very important in our daily life because of the unlimited increase of cars and transportation systems which make it impossible to be fully managed and monitored by humans, examples are like traffic monitoring, tracking stolen cars, managing parking toll, red-light traffic violation enforcement, border, and customs checkpoints. Yet it is a very challenging problem, due to the diversity of plate formats, different scales, rotations, and non-uniform illumination conditions during image acquisition. This system is approach based on simple but efficient Sobel edge detection method for plate localization. This approach is simplified to segment all the letters and numbers used in the number plate by using bounding box method character segmentation and then to use Template Matching to recognize of numbers and characters. The concentrate is given to locate the number plate region properly to segment all the numbers and letters to identify each number separately.

ABSTRAK

Pengecaman plat nombor menjadi sangat penting dalam kehidupan seharian kita kerana peningkatan kereta dan sistem pengangkutan yang tidak terhad menjadikannya mustahil untuk diurus sepenuhnya dan dipantau oleh manusia, contohnya sangat banyak pemantauan lalu lintas, mengesan kereta yang dicuri, menguruskan tol tempat letak kereta, penguatkuasaan pelanggaran merah terang, tempat pemeriksaan sempadan dan kastam. Namun ia adalah masalah yang sangat mencabar, kerana kepelbagaian itu format plat, skala yang berbeza, putaran dan keadaan pencahayaan yang tidak seragam semasa pengambilalihan imej. Sistem ini adalah pendekatan berdasarkan kaedah pengesanan pinggir Sobel yang mudah tetapi cekap untuk penyetempatan plat. Pendekatan ini dipermudahkan untuk membahagikan semua huruf dan nombor yang digunakan dalam plat nombor dengan menggunakan pembahagian aksara kaedah pengikat kotak dan kemudian menggunakan Matching Template untuk pengiktirafan nombor dan aksara. Focus ini diberikan untuk mencari kawasan plat nombor dengan betul untuk menyatukan semua nombor dan huruf untuk mengenal pasti setiap nombor secara berasingan.

اوينور ستي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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LIST OF SYMBOLS

<i>NPL</i>	-	Number Plate Localization
<i>NPR</i>	-	Number Plate Recognition
<i>OCR</i>	-	Optical Character Recognition
<i>RGB</i>	-	Red, Green, Blue
<i>%</i>	-	Percentage
<i>GHZ</i>	-	Gigahertz



LIST OF ABBREVIATIONS

<i>GUI</i>	-	Graphical User Interface
ITS	-	Intelligent transportation systems
UteM	-	Universiti Teknikal Malaysia Melaka
CCA	-	Connected Component Analysis
NN	-	Neural Network



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CHAPTER 1

INTRODUCTION

1.1 Background

The Number Plate Recognition (NPR) was invented in 1976 at the Police Scientific Development Branch in the UK. Number plate is used for identification of vehicle in all over the world. Vehicles are identifying either manually or automatically. Number Plate Recognition (NPR) is an image processing technology used to identify vehicles by their number plates registration. Vehicle identification plays important role in intelligent infrastructure systems and intelligent transportation systems (ITS). Vehicle identification system used for the purpose applications such as unattended parking lots, security control of restricted areas, traffic law enforcement, congestion pricing, and automatic toll collection. Consequently, numerous unused algorithms have been created, particularly to identify the car number plate naturally. The identification of number plates is fraught with difficulties. Despite the numerous algorithms, differences in rules, shape, content textual style, colour, and format for the number plate in a specific country cause a few algorithms to fail to recognize the number plate. Furthermore, natural variables such as light, brightness, and dirt influence the result. In Malaysia, for example, the number plate may have two different designs: white numbers and letters on a dark background, or the other way around.

1.2 Problem Statement

Vehicles are now an important part of transportation, especially in Malaysia. As the number of vehicles on the road rises, traffic congestion will increase in certain areas, necessitating the development of a plate recognition system to address the issue. Since the parking lot at

UTEM are extremely restricted, parking management is a major issue for students at the Faculty of Engineering and Technology campus. The university can be the only car that third- and fourth-year students will use to access the school, but according to university records, the dilemma occurs from unregistered cars entering the campus due to some students attempting to duplicate a university sticker. For university, the program must verify whether the vehicle seeking entry has been registered with the university, which would necessitate the use of the database that stores vehicle details. This plate recognition system has been used in many countries, but it employs a few algorithms, resulting in variations in algorithm accuracy depending on the process employed. Since the algorithm has already shown its inability to identify the number plate and has not performed exceptionally well in comparison to traditional benchmark systems, it will be limited to only making Malaysian car plate numbers.



1.3 Project Objective

The objectives of this project are as follows:

- a) To develop an algorithm for the Number Plate Recognition System (NPRS) based on the Sobel Edge Detection, Bounding Box, and Template Matching techniques.
- b) To create a Graphical User Interface (GUI) that uses MATLAB tools to show information about cars in detail.

- c) To assess the algorithm's output accuracy using a traditional benchmarking method for number plate recognition.

1.4 Scope of Project

The aim of this project is to create a framework that uses image recognition to identify vehicles based on their number plate registration and country-approved number plate specifications. Following that, this machine can read each of the characters on the number plate and identify them using a MATLAB software-based algorithm. However, the aim of this project is to detect the number plate from the input images and then observe the results. Furthermore, this project will build an algorithm and GUI on MATLAB to show the output character of the plates to analyses the accuracy of results. There are some limitations in this project, such as the algorithm's inability to detect number plates when the picture taken is of the whole car, but only recognizes the number when the image is only of the number plate images. The algorithm is also restricted to Malaysian license plate numbers. Only the sample format of 24x42 pixels is used in the recognition process.

a)

1.5 Summary

By the conclusion of this chapter, I have a better understanding of the project's issue as the number of cars on the road increases, traffic congestion will increase in some areas, forcing the construction of a plate recognition system to handle the problem. As a result, we decided to use the Sobel Edge Detection, Bounding Box, and Template Matching methods to create an algorithm for the Number Plate Recognition System (NPRS). develop a graphical user interface (GUI) that shows detailed information about vehicles using MATLAB tools. As a result, the goal of this project is to develop a framework that uses image recognition to

identify cars based on their registration numbers and country-approved number plate standards. Following that, using a MATLAB software-based algorithm, this computer can scan each of the characters on the number plate and identify them.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This part will talk about the research of the related project. It will cover about the study and idea based on the previous project as well as the hypothesis accomplish of this project. The methods used for completing this project will be explained each part in detail.

2.2 Related Work

2.2.1 Automatics Number Plate Recognition on FGPA

Xiaojun Zhai, 2013[1] proposed a FPGA implementation to solving the ANPR algorithm included 3 methods of Number Plate Localization (NPL), Character Segmentation (CS) and Optical Character Recognition (OCR). The figure below shows a block diagram of the proposed system.

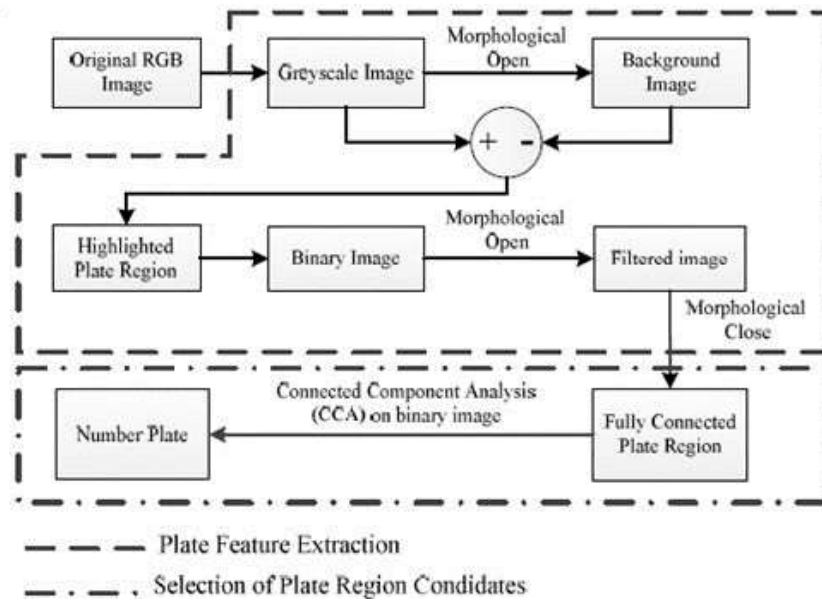


Figure 2.1: Block Diagram of NPL system

Based on the figure 2.1, the begin with open morphological task is capacity to separate the component of number plate and second open process is to expel the clamor. Although, the author also uses Connected Component Analysis (CCA) to mark the connected pixels from previous stage to binary images. Surajit Das, 2017 stated CCA scans and labels the pixels of a binarized image component, and every pixel is assigned with a value depending on the components. After that, the CS algorithm is used related on pixels and morphology process and also was divided by 3 stage it is pre-projection, vertical and horizontal projection. The diagram below appears the block diagram of CS system.

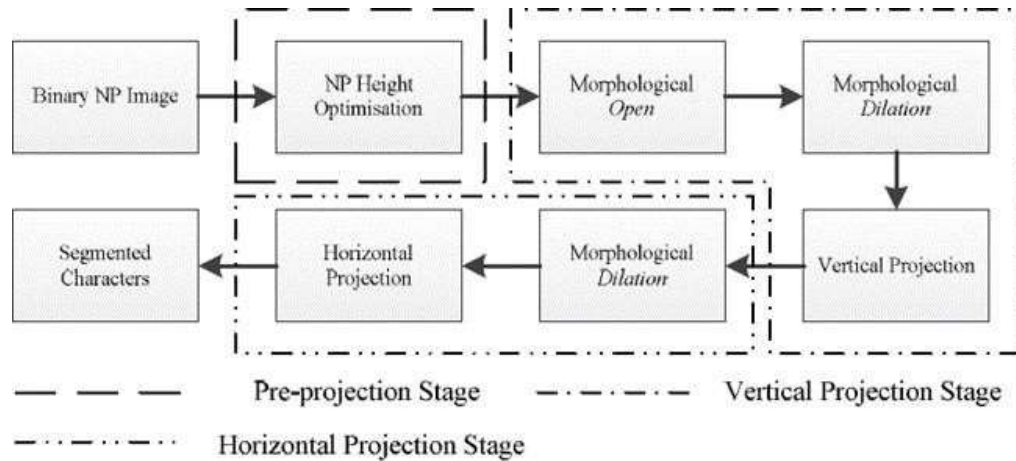


Figure 2.2 Block Diagram of CS system

According to the image above, a number plate height optimization was used to eliminate the unneeded section of the number plate, and then morphological and dilation methods were used to reduce the noise effect. The horizontal projection was then used to locate the letters' horizontal placements. After then, the author employed the OCR approach. To translate character pictures into machine code text, this approach employed a multi-layer feed forward Neural Network (NN). According to H. E. Khodke, a neural network is a data-processing facility that is impacted in the same manner as the biological nervous system, such as the brain, is. The architecture of a two-layer feed forward Neural Network is depicted in the diagram below (NN).

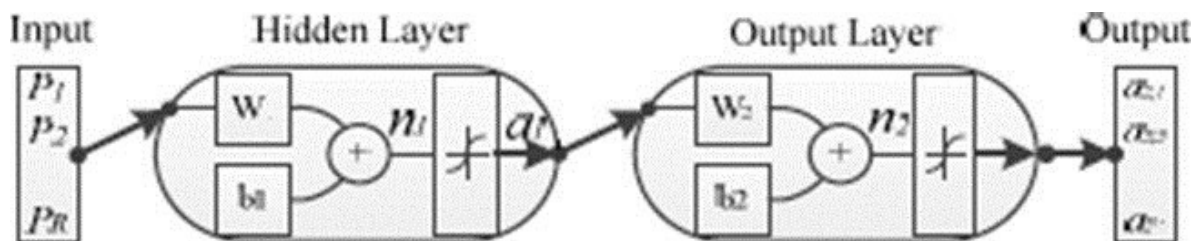


Figure 2.3 Architecture of Neural Network

Consequently, the ANPR systems used 80 percent of the Virtex-4 on-chip FPGA slices, while the remaining 20% was used to run the communication and display units. This

suggested system can only operate at a maximum frequency of 57.6 MHz, and the processing time for one picture is 11 milliseconds. Finally, the success rates for NPL, CS, and OCR segmentation are 97.8%, 97.7%, and 97.3 percent, respectively, and the total system accuracy of the proposed system is 93.0%.

Table 2.1 Comparison successful accuracy of proposed system

ANPR System	Character Set	Hardware Platform	Successful Rate (%)	Speed (ms)
[5]	Australia	TI C64 DSP	85	52.11
[19]	Turkey	FPGA Virtex-4	73	500
[20]	Japan	PC Intel Core 1.8 GHz	93.54	284
[21]	Chinese	PC 3 GHz	93.9	293
Proposed System	UK	FPGA Virtex-4	93.0	11

2.2.2 Malaysian Car Number Plate Detection and Recognition System

Choo Kar Soon suggested implementing a Malaysian auto number plate detection and identification system based on a mixture of AdaBoost and connected component analysis (CCA) techniques in 2012[2]. The goal of this research is to use the KNN classifier approach to detect unique number plates.

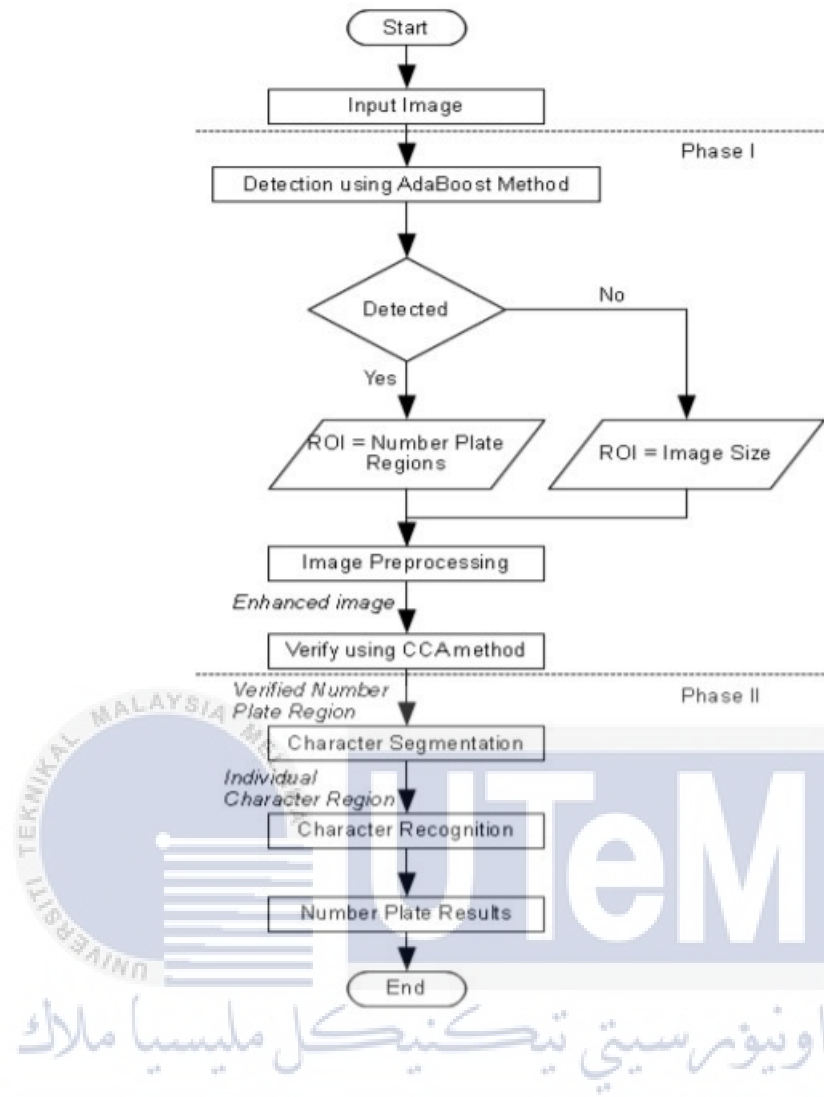


Figure 2.4 Flowchart of proposed system

The proposed framework comprises of number plate location dependent on blend of AdaBoost, CCA calculations, and character acknowledgment utilizing KNN technique as appeared in Figure 2.4.

In the detection step, the AdaBoost-based vehicle number plate finding computation requires offline training to obtain a robust classifier. During the training step, a large collection of images incorporating positive and negative number plate tests is necessary to enhance the strong classifier. During the AdaBoost computation for number plate disclosure,

a sub-picture must go through all the classifiers with the goal of being recognised as a number plate region.

Because detection results using the Adaboost methodology are frequently false positive, the CCA methodology is used to validate the detection zone to reduce false positives. Because only selected districts of interests (ROI) are involved, the CCA approach is simple and straightforward. CCA is used to find every associated portion (CC) in a ROI after a series of pre-processing steps.

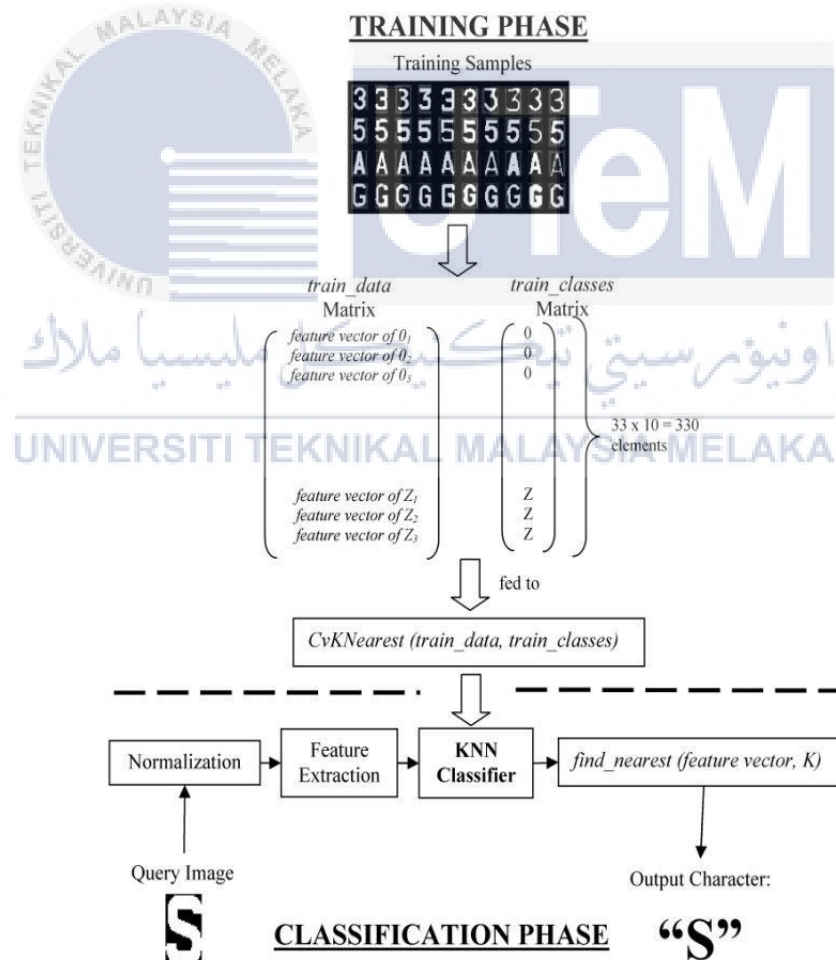


Figure 2.5 Design architecture of KNN methods

2.2.3 Car Plate Detection Engine Based on Conventional Edge Detection Technique

Hamam Mokayed suggested a licence plate identification system based on the conventional edge detection methodology in 2014 [3]. The goal of this research is to show how our created algorithms handle these difficult situations in the context of plate identification, from picture scene capture through plate presentation. The diagram below depicts the proposed system's overall procedure.

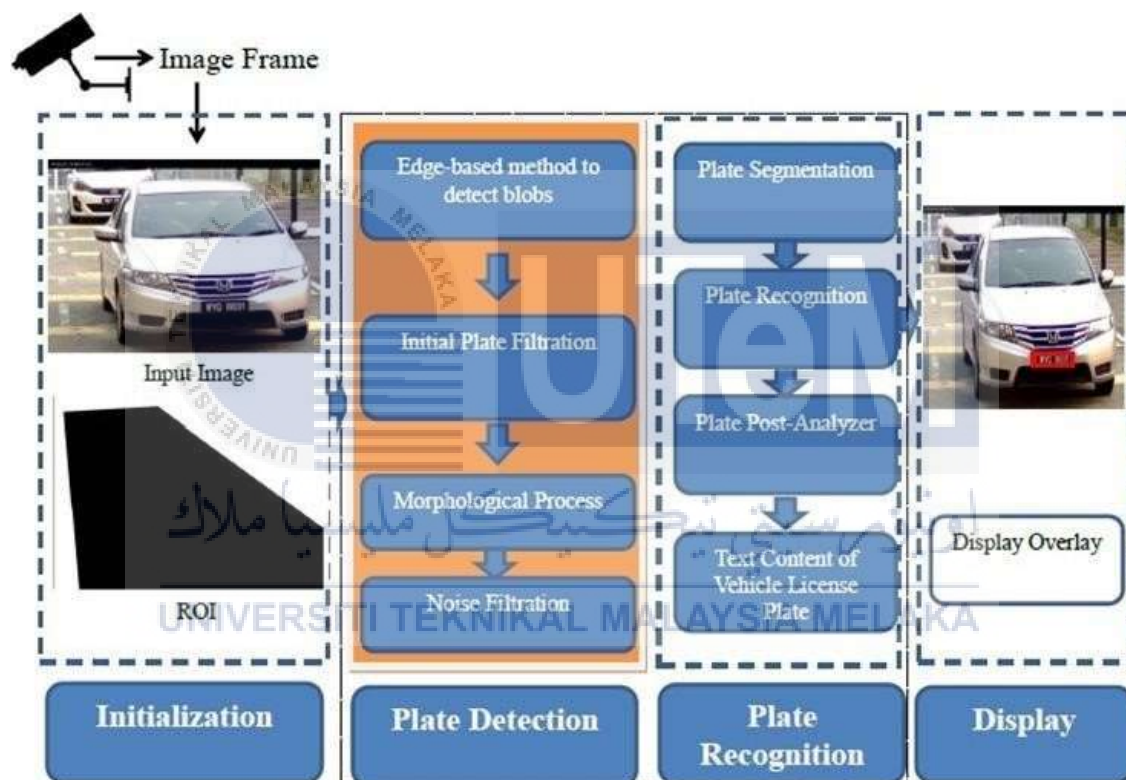


Figure 2.6 Overall process of license plate recognition system

The licence plate localization method searches for probable licence plates in images or frames from video with the goal of recovering the licence plate. Edge detection is then followed by mathematical morphology, and finally local statistics such as variance and edge statistics are produced. Edge detection methods are used to discover pixels with abrupt

variations in brightness that correspond to the edges of objects in a picture, according to Ibrahim Turkeyilmaz, 2017.

The final phase is noise filtration, which is used to execute condition-based filtering on the discovered blobs. Most automobile plate detection systems use algorithms that are based on the size of the blob, height and width ratios, compactness, coordinate value, and white pixel/black ratio. Finally, the results of this system demonstrate that the algorithm was evaluated in real-time with 522 images of Malaysian automobile plates, with an overall detection accuracy of 90.6 percent and 345 images successful with proper outputs

2.3 Feature Extraction for Vehicle Number Plate Detection

Swati Jagtap introduced feature extraction approaches based on the Histogram of Oriented Gradients in 2015. (HoG). The goal of this project is to verify the database of authorized users, and only authorized vehicles will be allowed to access the restricted area.[1] The suggested algorithms are depicted in the block diagram below.

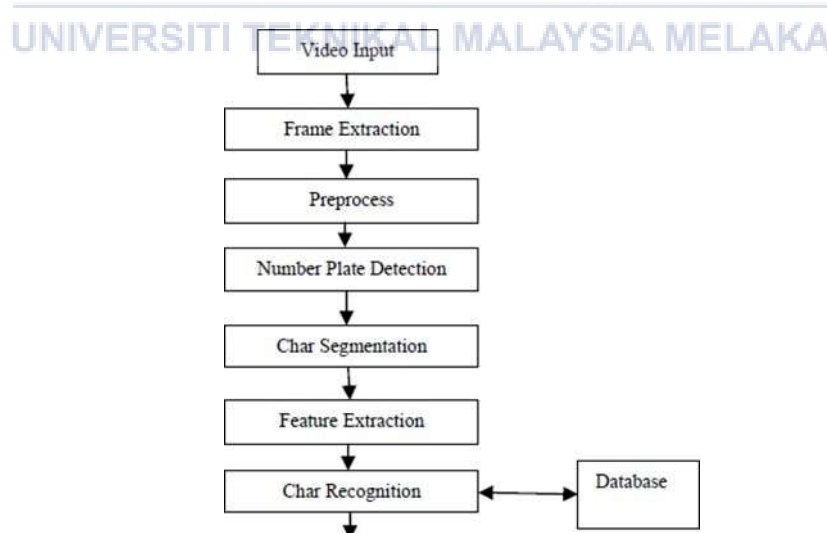


Figure 2.7Block Diagram of Proposed algorithms

According to the block diagram above, the frame will extract the video input that contains the vehicle's number plate. Following that, pre-processing will be used to

reduce noise from the frame, which will have an impact on recognition accuracy. The shading edge was also converted to a grayscale outline and the median filter was used during the pre-processing. To convert a colour image (RGB) to grayscale pictures, use Equation 1 below. The Sobel vertical edge detections are used by author to find out the region and morphology operation also used in this system to find out the location of number plate and the two-algorithm called Erosion and Dilated are used to solve the system. The QT tool and OpenCV images processing also used to across platform application framework to use for developing application software while OpenCV is library of programming function to focused on image processing.

Furthermore, the author uses a histogram of directed gradients throughout the feature extraction step (HoG). Nearby geometric and photometric changes have little effect on the HoG. The image is divided into cells in HoG, and the author computes a neighbourhoods 1D histogram of angle bearings over the cell's pixels. Following the merged histogram, differential normalization will be used to make the descriptor light and shadow invariant. The steps of HoG may be seen in the diagram below

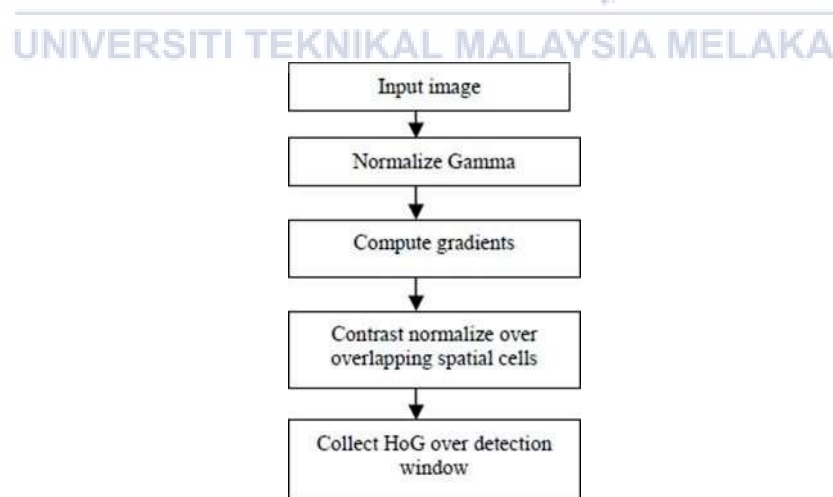


Figure 2.8Steps of HoG

Furthermore, straight introduction is used in both two spatial and slope introduction measurement to allow for small spatial and introduction changes. To achieve differentiate normalization, the cells are grouped into larger spatial parts and the differentiate of each

piece is normalized separately. The author used a database with many images with a resolution of 512x409 in the findings. The input outline capture from video for number plate position is shown in the image below.

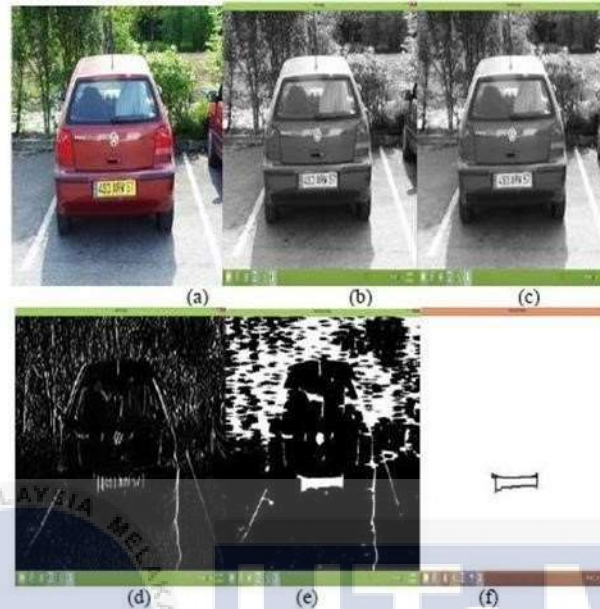


Figure 2.9 Plate Localization technique

2.2.5 Malaysia automatics number plate recognition system using Pearson Correlation

Wong Weng Keong, 2016 proposed a Malaysian automatic number plate recognition system that would use Pearson Correlation to monitor and recognize automobile number plates using vehicle plates as input [2]. The planned number plate recognition system is depicted in the diagram below

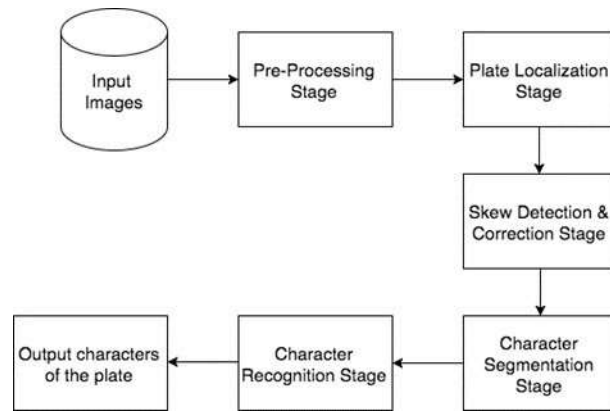


Figure 2.10 Architecture of Proposed system

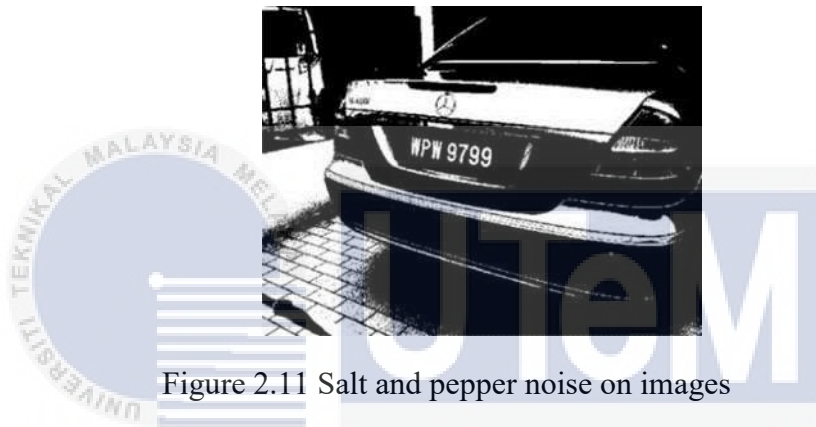


Figure 2.11 Salt and pepper noise on images

According to the diagram above, the first stage is pre-processing, which uses the input picture to improve picture quality and maintain the image area of the automobile plate. Furthermore, the multi-color picture will be converted to grayscale, and the grayscale picture will be converted to binary using a thresholds methodology based on Otsu's method. According to Velappa Ganapathy (2008), this methodology offers establishing an ideal threshold by reducing the total of within class variations of the object and background pixels. According to Joseph Tarigan (2017), the Otsu threshold was chosen because it can tolerate brightness variations. To achieve smooth photos, the median filters approach was used to reduce the effects of salt and paper noise, as seen in the picture below



Figure 2.12 Image after applying median filter

This element was designed to reduce existing spatial resolution by allowing for a more consistent amount of pixel area for each character on the vehicle's licence plate. As a result, evaluating these photos allows for a more exact determination of the appropriate threshold value. The result of performing the thresholding is shown in the diagram below.



Figure 2.13 Before present of thresholding (left) and later thresholding (right)

Plate localization is the following step, which classifies a territory of the car plate on the trimmed pictures. The horizontal and vertical projections of segmentation are utilized to determine the magnitude of the spatial resolution in this case. Because the gathered photographs are obtained from various edges positions of the camera, such as in the image below, the third stage is skew detection and rectification



Figure 2.14 +45 degrees (left), -45 degrees (middle) and 0 degrees (right)

The gradient denotes the steepness of a straight line and steepness may be detected using polynomial curve fitting on the obtained "x-axis" and "y-axis" vectors to produce two values of the line of best fit. As a result, curve digression is used to compute the intersection of the two lines that need to be aligned, as shown in the diagram below.

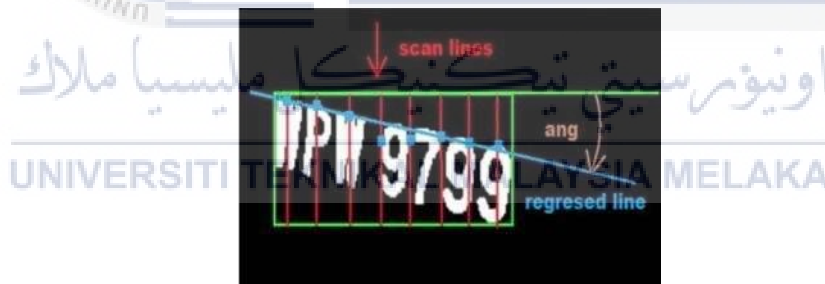


Figure 2.15 Angular techniques was analyzed

The character segmentation stage comes next. According to Ragini Bhat (2014), segmentation is one of the most crucial procedures in number plate identification since it provides the foundation for all subsequent procedures. In this stage, the author uses the bounding box methodology to arrive at a conclusion based on measuring linked components (objects) that are dependent on the pixel intensity of their neighbours. The ratio is defined as the width of the bounding box divided by the number of columns divided by the number of rows. Character recognition is the final stage in this system, and it ensures that the

recognition procedure is accurate. The database includes numbers (0-9) and letters (A-Z). The 2-D Pearson connection is then used to process the relationship rate between the input picture's pixel powers and all the layout characters in the database. The output generated by the suggested system is depicted in figure 2.16.

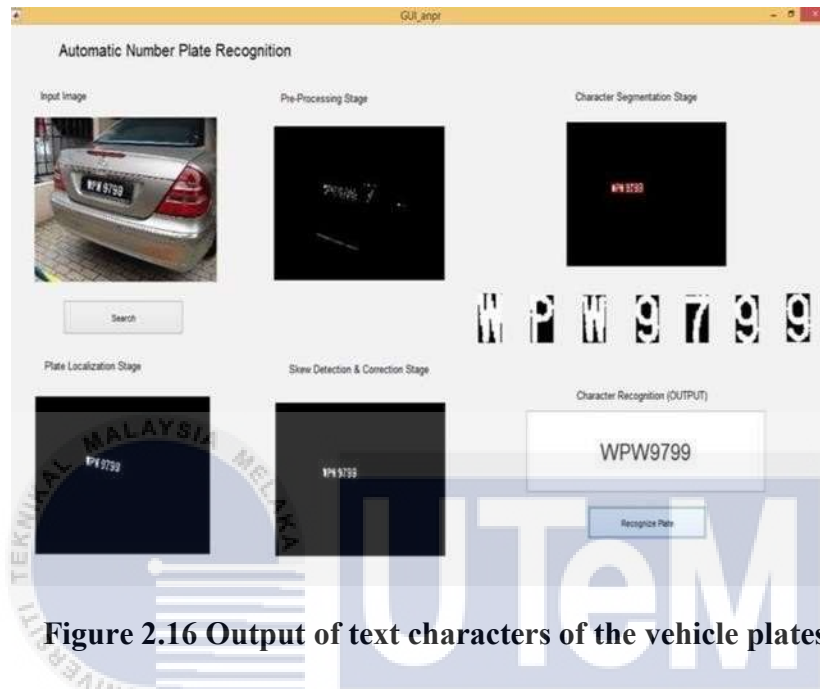


Figure 2.16 Output of text characters of the vehicle plates

Table 2.2 depicts the two types of number plates that are associated with Malaysia: standard and nonstandard. The results show a number of metrics, including character division precision, character acknowledgment precision, and computational time. Table 2.3 also shows the exactness of the framework under various illuminations, as well as the degree of skewness.

Table 2.2 Performance and Accuracy comparison

Reference	Types of Number Plate	Input Images	Classifier	LP Segmentation	LP Character Recognition	Average. Computational time
2	Standard Malaysian Plates	50	Template matching	N/A	N/A	N/A
3	Standard Malaysian Plates	150	KNN	90.5%	93.2%	N/A
4	Standard Malaysian Plates	100	ANN	98%	93%	N/A
5	Standard Malaysian Plates	50	Template matching	42%	52.4%	N/A
6	Standard Malaysian Plates	589	ANN	N/A	95%	N/A
7	Standard & Non-standard Malaysian Plates	300	Fuzzy Template Matching	98%	90.4%	1.7 seconds for Fuzzy, 0.75 seconds for Template Matching
8	Standard & Non-standard Malaysian Plates	500	Template Matching	N/A	81.33%	N/A
Proposed Technique	Standard Malaysian Plates	270	Template Matching	99.6%	91.5%	1.25 seconds

Table 2.3 Accuracy with different illumination and level of skewness

Illumi nation	No. of Input Images	-45 degree success rate	0 degree success rate	+45 degree success rate	Overall accuracy
Dark	90	28/30= 93.3%	30/30= 100%	23/30= 76.6%	81/90=90%
Normal	90	27/30= 90%	30/30= 100%	24/30= 80%	82/90=91.1%
Bright	90	25/30= 83.3%	30/30= 100%	28/30= 93.3%	83/90=92.2%

2.2.6 Car Plate Recognition System

Dening Jiang suggested a neural network and OCR approach for recognising car number plates in 2012 [3]. The goal of this project is to show that the approach utilised by the author is successful. The essential processes in the author's suggested plate identification system are depicted in the diagram below.

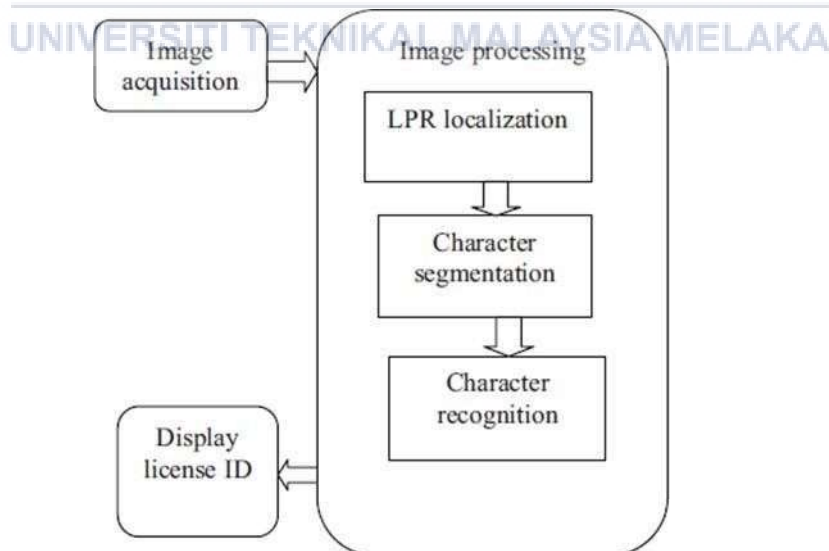


Figure 2.17 Main steps of Number Plate Recognition

Image quality will be increased during pre-processing. The contrast enhancement is necessary for the plate to be identified. Following that, the acquired picture will be transformed to grey scale before the plate recognition localization procedure. According to Allam Mousa (2012)[4], the image is smoothed by its conversion to grey scale, allowing the algorithm to detect the picture's boundaries. The author then uses the median filtering procedure to eliminate the salt and pepper noise from the image. The histogram equalization technique was employed in the brightness enhancement procedure. The formula for calculating stretched grey levels is shown in equation 2, where 255 represents the most extreme grey level in the improved image.

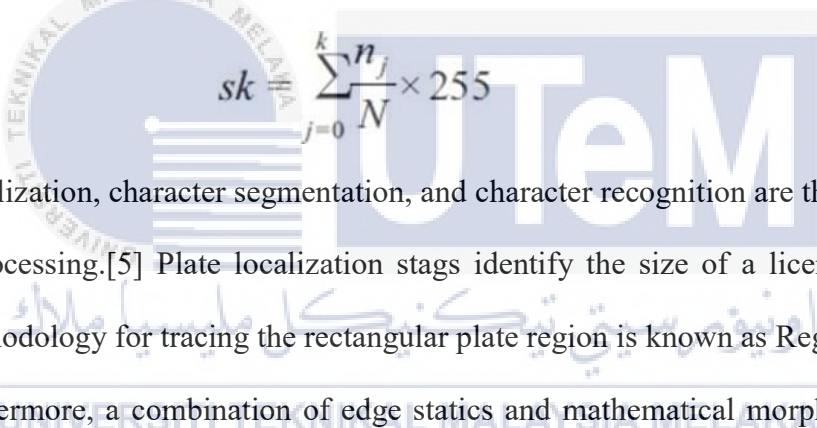

$$sk = \frac{\sum_{j=0}^k n_j}{N} \times 255$$

Plate localization, character segmentation, and character recognition are the three phases of image processing.[5] Plate localization stages identify the size of a licence plate. The author's methodology for tracing the rectangular plate region is known as Region of Interest (ROI). Furthermore, a combination of edge statics and mathematical morphology will be used to determine the number plate region in order to extract it. Mathematical morphology is utilised to compute the threshold value utilising multi-stage, according to K. Kiran Kumar, 2017.[6] Therefore, the region with the greatest edge magnitude and variance will be identified. The Sobel edge detection was also used in this part to highlight the areas. According to G. Naveen Balaji, a Sobel edge filter is used to determine picture boundaries.[7] When there is a sharp fluctuation in intensity gradient in a picture, it detects the edges. Before and after Sobel edge detection are shown in the diagram below.



Figure 2.18 Before Sobel edge detection applied.



Figure 2.19 After Sobel edge detection applied.

After the extraction of the number plate is normalised, the character segmentation stages of the number plate will differentiate each character. At this point, the author has normalised each character to the size of a binary picture (42x42) and will reformat the data to conventional dimensions before sending it to the neural network. The neural network was necessary to extend the data size, and as the data size grows, the system's productivity and accuracy improves. Finally, optical character recognition is used to recognise characters (OCR). OCR is a method that recognises individual alpha numeric characters on a licence plate, according to M. M. Rashid (2012). Figure below shows the number plate after being the segmentation.



Figure 2.20 After being of character segmentation

2.2.7 An effective method for plate number recognition

Jia Wang, 2017 , proposed Secondary Positioning, a new plate number localization methodology (SP).[3] To recognize a plate number, the HSV colour space and vertical edge approach were used, as well as Template Matching and the Artificial Neural Network (ANN) methodology in the character recognition phase. The first stage in the proposed methodology for removing the tangled backdrop. The image will then be converted to RGB and converted to HSV colour system. As previously learned hue and saturation portions of the red region, a binary image will be acquired identifying the red pixels in HSV colour space. The flowchart and HSV colour space approach utilised in this system are depicted in the diagram below.

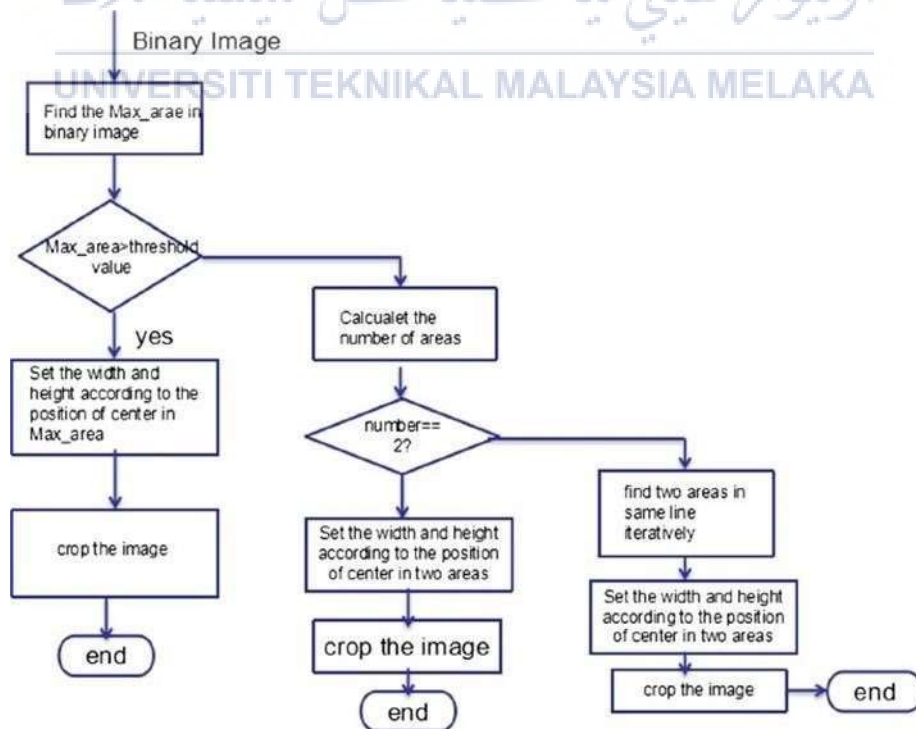


Figure 2.21 Flowchart to searching region



Figure 2.22 HSV color space method

Template Matching and ANN are executed in the framework during the Recognition step. The purpose of template matching is to coordinate a given picture district using several layouts, and then the template will determine which layout the provided photos belong to. Optical Character Recognition has made use of ANN (OCR). The neural network was created using a multilayer feed-forward-back technique with a single hidden layer.

The creator of the proposed system uses a database for plate number recognition that contains 80 images of cars and recognition testing images that are localized with a 75.8% accuracy compared to template matching (72.5%) used in character recognition, revealing that the counterfeit neural system has a higher precision (75 percent).

2.2.8 Automatics Number Plate Recognition System using Super-Resolution Technique

Balamurugan.G, 2015 described a system that uses visual input to recognise a vehicle's number plate and then uses a super determination technique.[8] The super resolution approach was used to increase the visual quality of the image by creating a larger verdict determination picture. Tejendra Panchal (2016) claimed that the Super resolution approach was used to increase the size of the LP so that adaptive thresholding could be

applied efficiently and effectively.[2] Optical Character Recognition (OCR) was used in this system to extract text from a high-resolution picture, which was then compared to the RTO database[8]. The architecture of the proposed number plate recognition system is depicted in the diagram below.

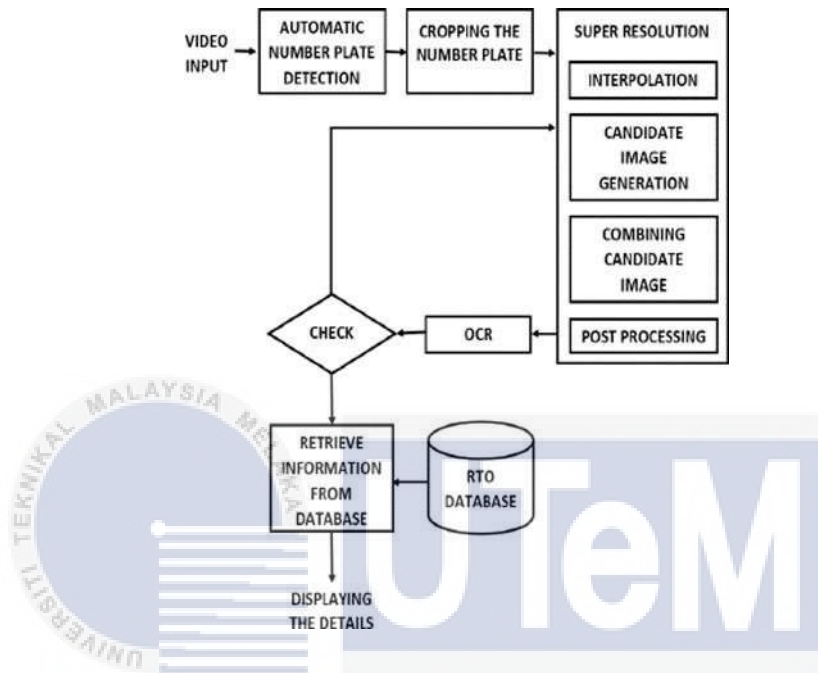


Figure 2.23 Architecture of the Framework

The image below depicts the number plate determination. The input video is first acquired from the reconnaissance, after which the developer performs number plate discovery inside the video outline to naturally find the number plate using the suggested technique. After then, the number plate from the video capture image will be clipped.

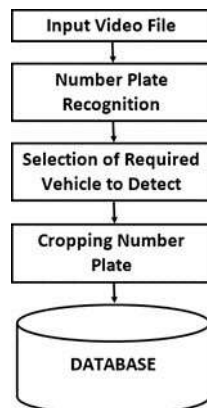


Figure 2.24 Selection of number plate region

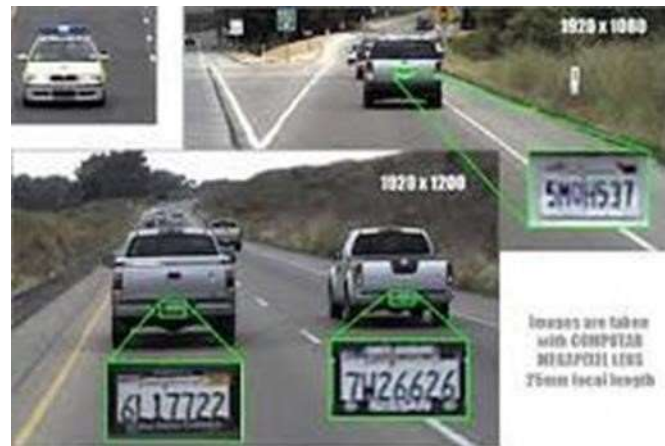


Figure 2.25 Input video and selecting wanted zone

Super resolution is defined as the ability to produce a high picture determination from a low image determination. Interpolation, development of an arrangement of application photos, merging competitors to offer a single picture, and post-handling are the four primary steps in the suggested method. The Spline Interpolation is used in this method to generate smoother edges.

Based on the earlier image, post planning is given. The MRF shown in the previous image is a multifunctional high-arrange MRF (Based on Picture Earlier). Every pixel is thresholded to find the true edges. Characters and text from the number plate were recovered using the (OCR) technology.[8] The block diagram of the OCR system is shown below.

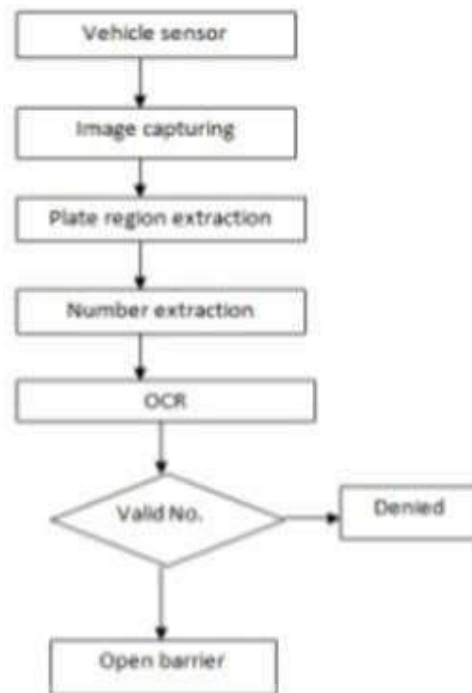


Figure 2.26 Block for Optical Character Recognition

The vehicle's detail is displayed in the last step of this method. When the data from a car's number plate is compared to the RTO database, it displays the owner's information; if the owner's information isn't located, the vehicle's detail isn't accessible.[1]

2.2.9 Malaysian Car Number Plate Detection System Based on Template Matching and Colour Information

Mohd Firdaus Zakaria suggested a technique for matching template and colour information in Malaysian car number plate recognition algorithms in 2010. To eliminate the undesired colour zone of the number plate area, the template matching approach is used to determine the region of number plate area and colour information. The block diagram of the suggested methodology is shown in the image below.

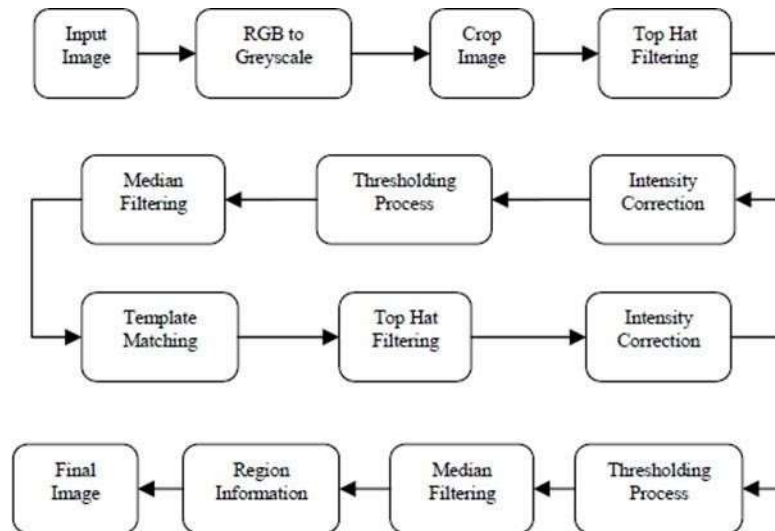




Figure 2.27 Block diagram of proposed technique

To get the intensity information, the image will first be converted into RGB (grey scale picture). Following that, the input will be cropped, with just 50% of the lower section of the image being processed because the top section does not have a number plate region. The top hat, intensity correlation, thresholding, and median filter techniques are then used to locate the number plate region twice more, yielding the result.

This method identifies the edge of the pictures during the template matching procedure. The matching procedure will then move the template image to every possible spot in the massive source image, then calculate a number list to identify the template images that are matched. According to Pratishta Gupta (2014), the template matching block compares the actual image's pixel-by-pixel value to one of the template pictures and returns the template metric value. The author utilised a 166x59 pixel template for this project. The top hat filtering sifting was used during the procedure to push the bottom white region without affecting the number plate clarity. [9]



Table 2.4 Effect of Distance parameter

Distance	Output Image
Parameter = 12 pixels	
Parameter = 6 pixels	

Because of the aforementioned, gap parameter 12 pixels will provide a better level of clarity in the number plate area than gap parameter 6 pixels, as the number plate region is clearer than the other portions. The brightness and illumination are important for the number plate detection at this point.

The threshold is then applied to convert the grayscale picture to binary. The 5x5 median filtering is also used in this system to minimise noise in binary images. The outcome is shown in the table below for various distance parameters used in the input image.

Table 2.5 Effect of Distance parameter for input image

Distance	Output Image
Parameter = 12 pixels 5 x 5 median filtering	
Parameter = 6 pixels 5 x 5 median filtering	

The color information approach was similar to the template matching approach in that the image had to be converted to grayscale and then top hat filtering was used to alter the

light when the input picture's foundation was faint. Following that, the contrast of the image must be adjusted to clear the plate region. The output with top hat filtering and contrast correction applied to the input picture is shown in figure 2.28. [9]



Figure 2.28 (a) Top hat filtering. (b) Contrast correction

Although, a binary picture was used to identify the number plate region. Later, the threshold value in MATLAB will be set to 0.85, and a median filter with a size of 5 by 5 will be used to eliminate noise from the input picture. Gray level cannot eliminate sounds, according to Soma Mukherjee (2015), hence median filtering is used to eliminate sounds from the image. The outcome of binary image and median filtering applied to a number plate is shown in figure 2.29.



Figure 2.29 (a) Threshold Image. (b) Median Filtering Image

Furthermore, the suggested system is run on MATLAB using an AMD Athlon 64 2GHZ processor. As a result of the findings, the algorithm proposed by the author can accurately identify the number plate area, but it cannot detect the position of the number plate with a rectangular template because the rectangular measure differs from the template measure used in the system suggested. Overall, the proposed procedure yielded 97.1 % better results than 66.19 % using colour information and 88.7 % using the template matching approach. The graph below depicts the overall test result of the suggested system as seen by the author.[9]

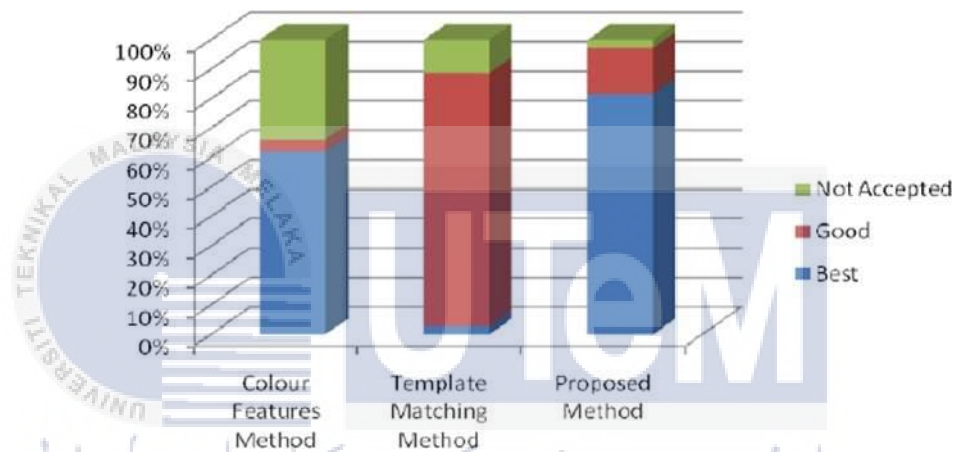


Figure 2.30 Overall test result

Wisam Al Faqheri suggested a hybrid fuzzy method to segment and recognize vehicle Malaysia number plates with varying lengths of character and numbers. [10]The creator of this research focuses on two goals: detecting standard number plates using a fuzzy logic system and then recognizing non-standard number plates using the Template matching theorem approach. The flowchart of proposed algorithms is shown in the diagram below.

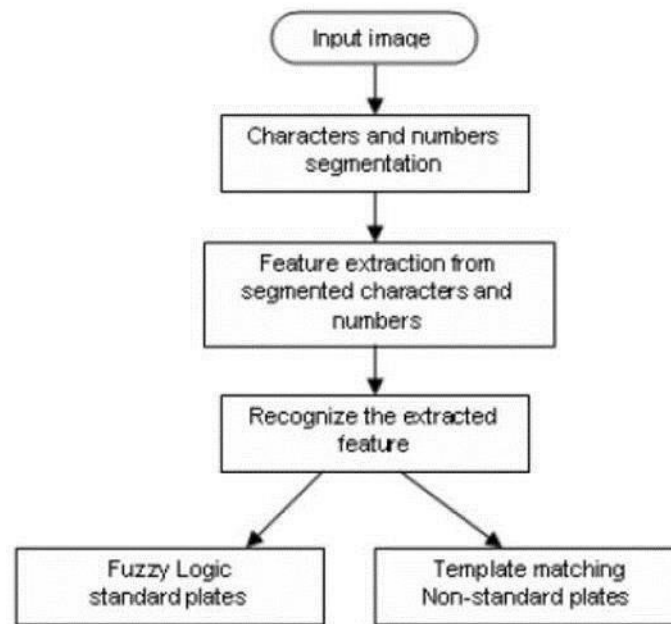


Figure 2.31 Flowchart of suggested algorithms

The quality of the input picture is critical in the pre-processing phase for segmentation and recognition. When converting a grayscale image to a threshold image, the picture will have noise or tiny objects, hence the morphological approach is used to eliminate the noise. There are varying lengths of forms in Malaysia, and they are divided into two groups: standard registration plates and non-standard registration plates.

So, if a character has three or less characters, the number plate is recognized by a fuzzy system; if there are more than three characters, the number plate is recognized by the Template matching theory. The illustration below depicts an example of a standard and nonstandard car number plate in Malaysia.



(a)



(b)

Figure 2.32 (a) Standard plate (b) Non-standard plate

Following that, the start and last columns for each letter and number will be detected, allowing them to be separated from the backdrop of the number plate. Many factors, such as lighting, blurring, and slope, might impact this process. To reduce the inaccuracy, the author employed vertical scanning to locate the starting and end column before moving on to horizontal scanning. The procedure of vertical and horizontal scanning segmentation is depicted in the diagram below.



Figure 2.33 (a) Vertical segmentation (b) Horizontal segmentation

In Malaysia, there are so many different types of automobile plates that it's impossible to keep track of them all. In addition, for standard number plate matching and template matching for non-standard number plates, a fuzzy logic system was used. The fuzzy system will recognise standard number plates with high accuracy and speed to meet the real-time system requirements, as well as adaptability to identify diverse number plate lengths. The author, on the other hand, combined the number and character into a single set-in order to provide versatility in their framework for recognising diverse shapes and textual fonts. Excellent speed processing and high recognition accuracy are required in this system, and the processing time to segment big words will be reduced. As a result, the author uses the template matching theorem to achieve excellent recognition accuracy while simultaneously reducing the processing time for segmenting these words.

The fuzzy logic and template matches demonstrate to be the most precise and

efficient theorem for real-time processing systems, according to the results. Overall, the results show that the hybrid approach is accurate, with a flawless plate accuracy of 100% and a loud and hazy picture accuracy of 95.5% in this system. The fuzzy system can analyse one plate in as little as 1.7 seconds, and template matching can detect a hazy picture in as little as 0.7 seconds, albeit it will be quicker if the photos are not blurry.



Figure 2.34 Types of Number Plate Layout

2.2.10 Bounding Box Parameterization

We propose to regress the bounds of a bounding box independently using a two-stage object detector Faster R-CNN or Mask R-CNN [42, 17] as illustrated in Figure 2.35. The bounding box representation as a 4-dimensional vector is (x_1, y_1, x_2, y_2) \mathbb{R}^4 , where each dimension denotes the box border position. Instead of the (x, y, w, h) coordinates used by R-CNN [13], we utilise the parameterizations of the (x_1, y_1, x_2, y_2) coordinates:

$$\begin{aligned} t_{x_1} &= \frac{x_1 - x_{1a}}{w_a}, t_{x_2} = \frac{x_2 - x_{2a}}{w_a} \\ t_{y_1} &= \frac{y_1 - y_{1a}}{h_a}, t_{y_2} = \frac{y_2 - y_{2a}}{h_a} \\ t_{x_1}^* &= \frac{x_1^* - x_{1a}}{w_a}, t_{x_2}^* = \frac{x_2^* - x_{2a}}{w_a} \\ t_{y_1}^* &= \frac{y_1^* - y_{1a}}{h_a}, t_{y_2}^* = \frac{y_2^* - y_{2a}}{h_a} \end{aligned}$$

Figure 2.35 R-CNN or Mask R-CNN where the projected offsets are tx_1, ty_1, tx_2 , and ty_2 . The ground-truth offsets are $t_{x_1}, t_{y_1}, t_{x_2}$, and t_{y_2} . The anchor box is

represented by $x1a$, $x2a$, $y1a$, $y2a$, wa , and ha . The anticipated box contains the values $x1$, $y1$, $x2$, and $y2$. Because we may optimise each position individually, a bounding box coordinate is labelled as x in the following sections. Along with the location, we want to assess the localization confidence. Instead of only predicting the placement of bounding boxes, our network predicts a probability distribution. Though more sophisticated distributions, such as multivariate Gaussian or a combination of Gaussians, might be used, we assume the coordinates are independent in this study and utilise single variate Gaussian for simplicity:

$$P_{\Theta}(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-x_e)^2}{2\sigma^2}}$$

where is the collection of parameters that can be learned. The predicted bounding box position is given by x_e . The standard deviation is a measure of the estimation's uncertainty. When the value is 0, it signifies that our network is quite confident in the position of the predicted bounding box. A completely linked layer on top of the fast R-CNN head creates it (fc7).

2.2.11 AN EDGE DETECTION MODEL BASED ON SOBEL OPERATOR

Sobel has two major benefits over other edge operators: CD Since the average factor was introduced, it has had a smoothing impact on the image's random noise. Because it is a two-row or two-column differential, the components of the edge on both sides have been strengthened, making the edge seem thick and dazzling. Edge detection in the airspace is normally done with the help of a local operator.[3] The orthogonal gradient operator, the directional differential operator, and a few additional operators related to second-order differential operators are often used. A kind of orthogonal gradient operator is the Sobel operator. The gradient operator is a derivative operator, and it relates to the first derivative. In the position (x, y) , the gradient of a continuous function $f(x, y)$ may be written as a vector (the two components are two first derivatives in the X and Y directions, respectively):

$$\nabla f(x, y) = \begin{bmatrix} G_x & G_y \end{bmatrix}^T = \begin{bmatrix} \frac{\partial f}{\partial x} & \frac{\partial f}{\partial y} \end{bmatrix}$$

The magnitude and direction angle of the vector are:

$$mag(\nabla f) = |\nabla f| = \sqrt{G_x^2 + G_y^2}$$

$$\phi(x, y) = \arctan\left(\frac{G_y}{G_x}\right)$$

For each pixel position, the partial derivatives of the formulae above must be determined. To approximate, we often employ small area template convolution in practise. G_x and G_y both need a template, hence a gradient operator must be composed of two templates. Sobel's two 3x3 templates are shown as (a) and (b). Every point in the image should use these two kernels to do convolution. One of the two kernels has a maximum response to the vertical edge and the other has a maximum response to the level edge. The maximum value of the two convolutions is used as the output bit of the point, and the result is an image of edge amplitude.

-1	-2	-1
0	0	0
1	2	1

(a) Convolution template S1

-1	0	-1
-2	0	2
-1	0	1

(b) Convolution template S2

Figure 2.36 Sobel edge operator Their

convolution is as follows:

$$g_1(x, y) = \sum_{k=-1}^1 \sum_{l=-1}^1 S_1(k, l) f(x+k, y+l)$$

$$g_2(x, y) = \sum_{k=-1}^1 \sum_{l=-1}^1 S_2(k, l) f(x+k, y+l)$$

$$g(x, y) = \sqrt{g_1^2(x, y) + g_2^2(x, y)}$$

If $g_1(x, y)$ is greater than $g_2(x, y)$, an edge with a vertical direction passes through the point (x, y) .

Otherwise, the point will be traversed by an edge with a level direction. If the pixel value of the

point (x,y) is f(x,y), and f(x,y) meets one of the following two requirements, this point is considered an edge point.

$$1) (1) g(x,y) > 4 \times \sum_{i=1}^{row} \sum_{j=1}^{list} g^2(i,j) / row \times list$$

$$(2) g_1(x,y) > g_2(x,y)$$

$$(3) g(x,y-1) \leq g(x,y)$$

$$(4) g(x,y) \geq g(x,y+1)$$

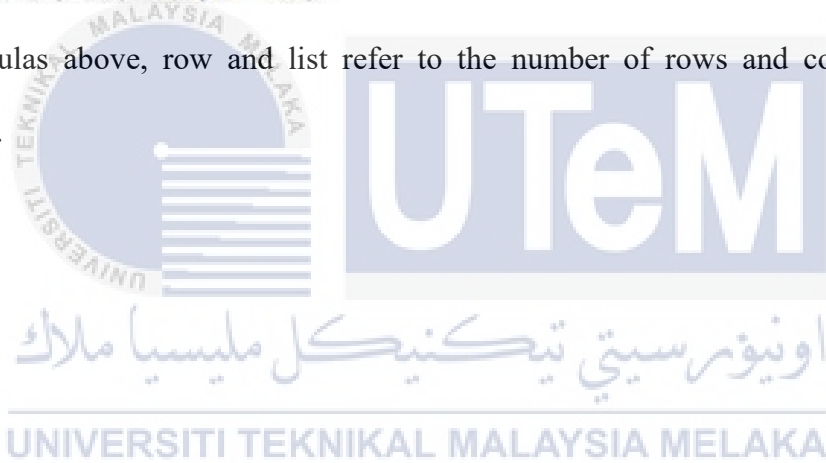
$$2) (1) g(x,y) > 4 \times \sum_{i=1}^{row} \sum_{j=1}^{list} g^2(i,j) / row \times list$$

$$(2) g_1(x,y) > g_2(x,y)$$

$$(3) g(x-1,y) \leq g(x,y)$$

$$(4) g(x,y) \leq g(x+1,y)$$

In the formulas above, row and list refer to the number of rows and columns of the image respectively.



2.2.12 Table of comparison

Author Name & Year	Objectives	Methodology	Outcomes
Xiaojun Zhai et al. (IEEE 2013) [1]	To complete the ANPR system using FGPA implementations.	Number plate Localisation(NPL), Character Segmentation(CS) and Optical Character Recognition(OCR).	The successful segmentation rate for NPL,CS and OCR is 97.8%,97.7 and 97.3% and overall system accuracy is 93.0%.
Choo Kar Soon et al. (ISNN 2012) [2]	To detected number plate and recognized using KNN classifier method.	AdaBoost and connected component analysis (CCA) algorithms and character recognized using KNN classifier method.	Achieve detection rate of 98% and recognition rate of 95% on static images and video sequences.
Hamam Mokayed et al. (ISBN 2014) [3]	To developed algorithms that challenging conditions in the context of plate detection from image scene acquisition.	The conventional edge detection of proposed system consists of several standard basic steps such as license plate localization, morphology process and noise filtration.	The overall accuracy of the detection is 90.6 % with 522 image Malaysian car plates in real-time.
Swati Jagtap (IJCSIT 2015) [4]	To checked the database of authorized user and only authorized vehicle will be to enter the limited region.	Feature extraction strategy utilizing Histogram of Oriented Gradient (Hog).	Vehicle recognizable proof depends on number plate discovery utilized the database of larger number of picture of dimension 512x409.
Wong Weng Keong et al. (IEEE 2016) [5]	To monitor and detect car number plates by examine vehicle plates as input.	Pearson Correlation and Template matching technique are proposed to maintain the accuracy of the car plate at the high level condition.	Proposed algorithm achieved 91.5% of overall accuracy in this project.

Dening Jiang et al. [IEEE 2012) [6]	To prove the method was used are effectively compared with another methods.	Proposed neural network and OCR method to recognition the number plate of vehicles.	The system capable to extracting the desired information in high percentages of the test image.
Jia Wang et al. [Springer 2017) [7]	To identify the proposed method are better than with algorithm already used in nowadays.	A novel plate number localization algorithm called Secondary Positioning (SP) is proposed and The three major recognition approaches template matching, artificial neural network based on OCR methods.	Achived 75.8% accuracy in localisation phase and template matching (72.5%) and ANN shows better accuracy (75%).
Balamurugan.G et al. [IEEE 2015) [8]	To find the information and details of the vehicle and also owner details will be displayed.	The super resolution technique utilized increase the visual quality and (OCR) applied to acquire the text from super resolution image then it compared with the RTO database.	The OCR will be analyse the text with RTO database and then the details of the vehicle and their owner details will be displayed.
Mohd Firdaus Zakaria et al. [IJCSSE 2010) [9]	To detect Malaysia car number plate with an efficiency algorithms.	Template matching and colour information to perform the detection stage in recognition plate.	Overall result are increase to 97.1% compared to 66.19% using color information and 88.7% utilizing template matching method.
Wisam Al Faqheri et al. [IJCSNS 2009) [10]	To recognize standard number plate by using Fuzzy logic system and to recognize nonstandard number plate by using Template matching.	The hybrid fuzzy system technique used to segment and recognize of vehicle Malaysia number plate automatically.	The results show the accuracy result on hybrid method which is 100% for ideal plate and 95.5% for the noisy and blurry images.

2.2 Summary

The number plate segmentation algorithms in most of the literatures, as mentioned at the conclusion of this chapter, work under limited situations such as light, number plate form, size, distance between camera and vehicle, and colour. Only a few algorithms function for a number plate; otherwise, the static picture of the number plate is sent to ANPR for further processing.



CHAPTER 3

METHODOLOGY

3.1 Introduction

This section will clarify and talk about the stream and a few strategies, and the methods attempted within the course of the final year project. It is more on the venture arranging and thought to assure that the project development will be gotten to be effortless and follow appropriately. A portion of the methodology are feature the progression taken to finish this kind of project.

3.2 Methodology

In arrange to attain a great result, there are a few ways and steps must be followed. All these steps will ensure that all the process of this project will went smoothly based on the schedule. Initially, gather all the information related to the project. All the gathered information must be considered inside the operating theatre.

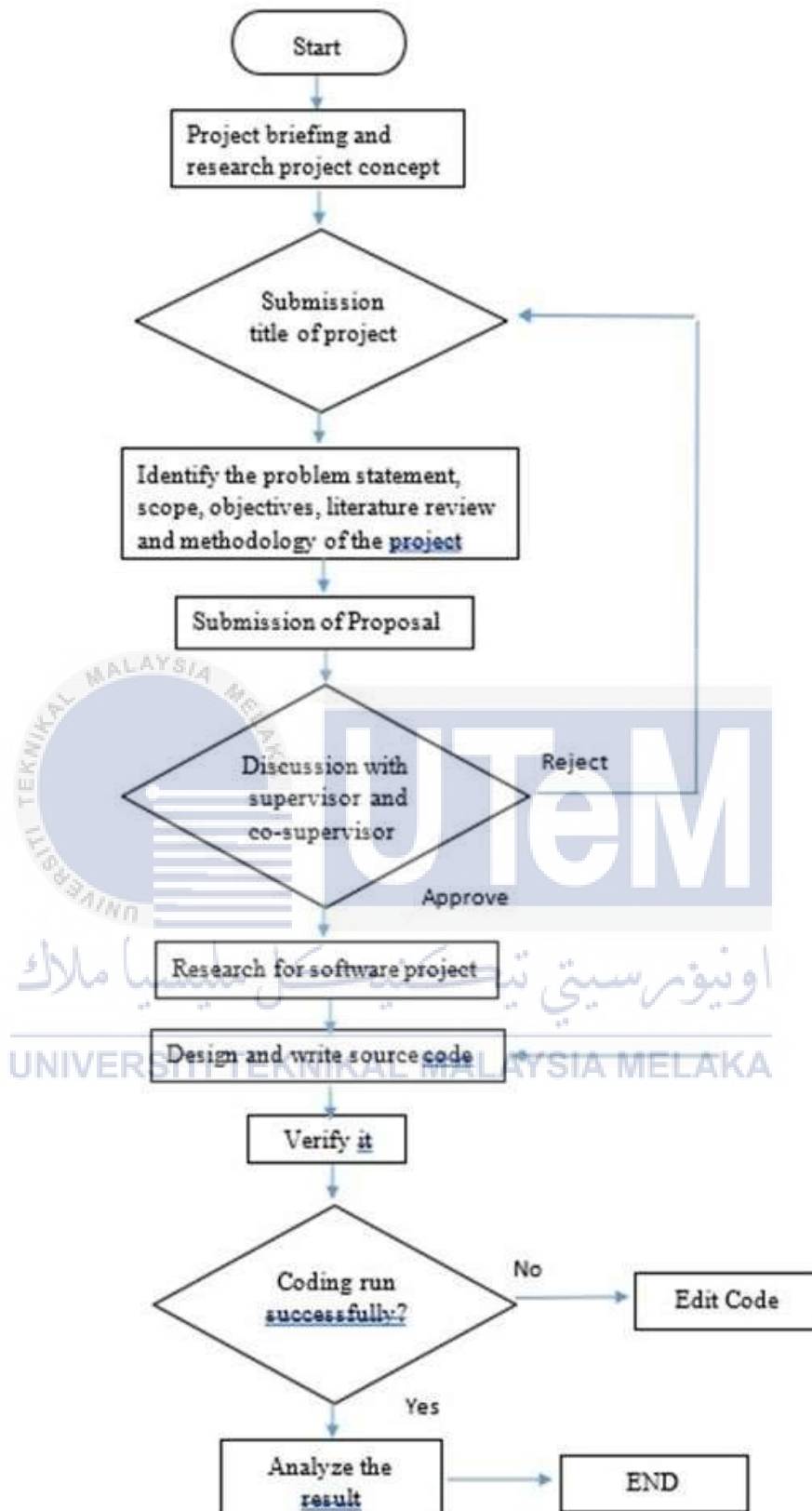


Figure 3.1 Flowchart of Project Development

3.2.1 Experimental setup

The concept of the project will be analyzed based on the flow chart above, where a supervisor decision is necessary to confirm this project. After the supervisor has given his approval, the project may begin to take shape. Since it is necessary to execute the concept to the project, a conversation with the supervisor is usually required.

After that, the research about software will begin. The MATLAB software are important in this project for implementation image processing. The MATLAB used in this project because the MATLAB contains a wealthy library capacity for picture handling and information investigation. This makes MATLAB a perfect instrument for quicker usage and confirmation of any algorithm.

Following that, the project's development will continue with the creation of a source code that will allow this system to be completed with precision and efficiency. After creating the source code, it must be verified before being run to obtain the desired results. When a source code has an error, the source code must be redesigned, and a new source code must be written till the source code is successfully executed. From that, after the source code has completed its execution, the output will be evaluated, and the data will be gathered.

According to the block diagram below, number plate recognition has three key steps that must be completed for the system to function properly. Number Plate Localization (NPL), Character Segmentation (CS), and Character Recognition are the steps (CR). To begin, a digital camera will be used to capture the input image. To increase image quality, color photos will be converted to grayscale photos during pre-processing. The Sobel edge detector is used to identify the number plate character during plate localization phases.

After that, using the bounding box approach, character segmentation steps are used to separate each character and number. In the last phases, the template matching uses character recognition to identify the edge of the pictures and then determines whether the template pictures are matched. If the template matches, the output character for number plates will be shown correctly.

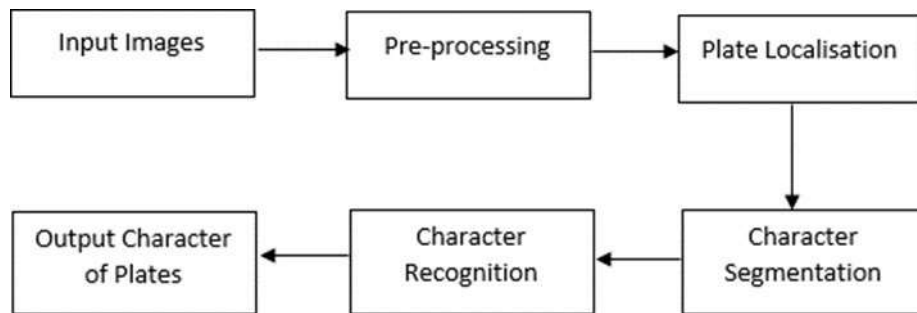


Figure 3.2 Block Diagram of Project System



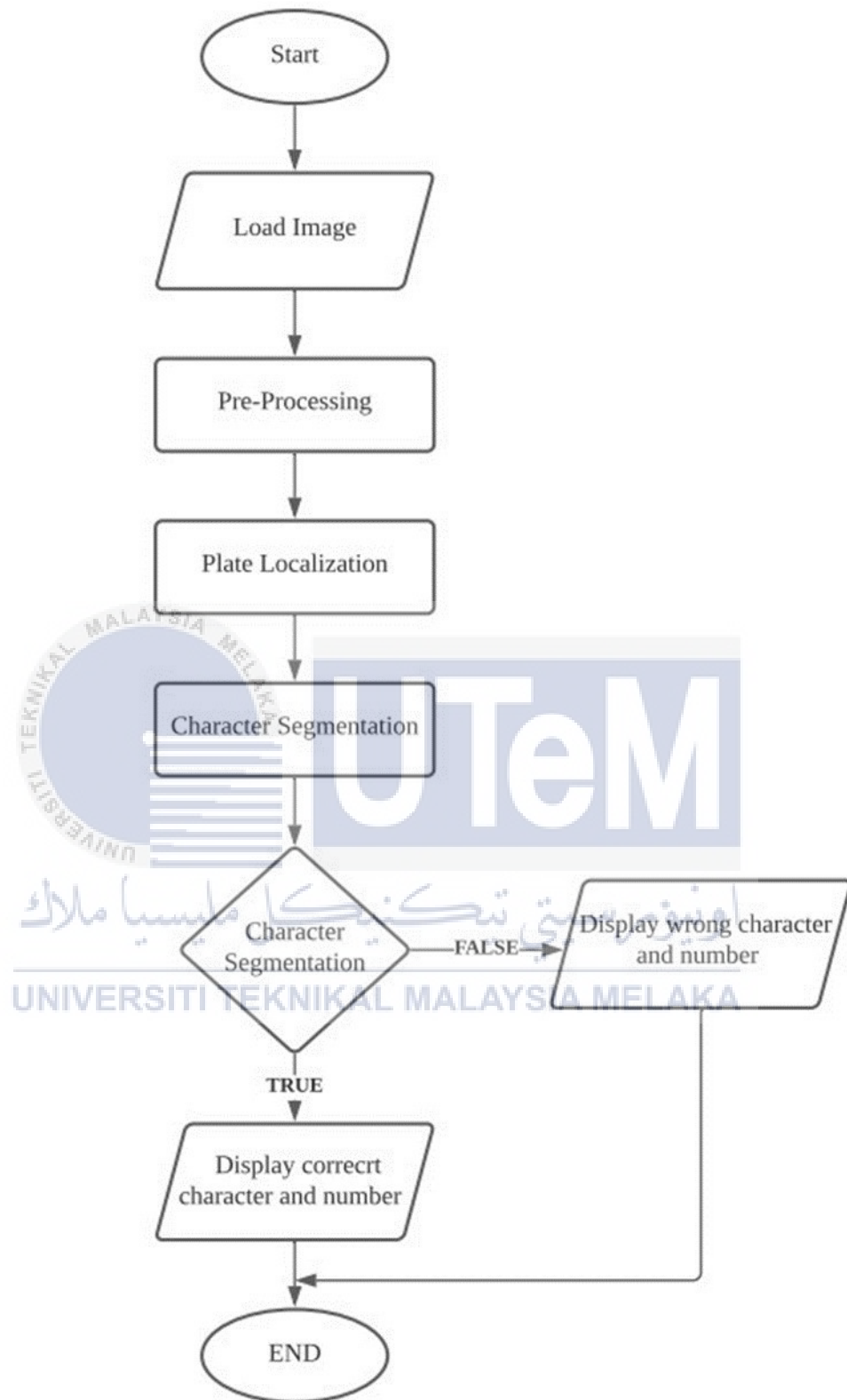


Figure 3.3 Flowchart of Project system

3.2.1.1 Pre-Processing

Pre-processing is mostly used to improve image quality and minimize noise. Gray scale images are used to transform number plate images as input. By removing the hue and saturation information while keeping the brightness, the (rgb2gray) function transforms RGB pictures to grayscale. By producing a weighted total of the R, G, and B components, Rgb2gray transforms RGB data to grayscale values.



Figure 3.4 Grayscale image

3.2.1.2 Plate Localization

The main function of the module is to find out the potential regions within the image that may contain the number plate from the input image of car or any vehicles. Sobel edge detection was used to perform a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. It's used to calculate the horizontal and vertical values of the estimated absolute gradient magnitude at each location in a grayscale picture. Median filtering, erosion, dilation, thresholding, complement, and pixel removal are the six minor processes in this step. Every operation will employ a unique algorithm that was created using the MATLAB programmed.

3.2.1.3 Median Filtering

The median filter is commonly used to reduce impulsive, or salt-and-pepper noise in photographs. It may also be used to keep an image's edges while eliminating random noise and smoothing it down. Although, median filtering is used to smooth out the picture from an object's colour, split narrow isthmuses, and remove thin protrusions.



Figure 3.5 Median filtering algorithm

3.2.1.4 Edge Detection

After enhancement of image the edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in the image.



Figure 3.6 Edge Detection

3.2.1.5 Image Dilation

Dilation is a morphological procedure that involves filling gaps in an image, sharpening the edges of objects in an image, joining broken lines, and increasing the brightness of an image. It also ensures that the picture is dilate and thicker than its original size for a better appearance. As a result, the picture will get brighter and thicker, allowing it to go on to the next image processing phase.

3.2.1.6 Image Thresholding

A binary image is a computer image in which each pixel can only have one of two values: 1 or 0, with 0 representing white and 1 representing black. The image pixel with value 0 (white) becomes 1 (black) in the complement of a binary picture, and the image pixel with value 1 becomes 0, reversing the white and black colours of the picture.



Figure 3.7 Image complement

3.2.1.7 Pixel Removal

Digital images are prone to various types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. The `rp = bwareaopen(im, 500)` removes all connected components (objects) that have containing fewer than 500 pixels from the binary image in image complement. Although, `final = bwareaopen(rp, 500)` remove all region that are of pixel area more than 500 pixels from binary image.

```
im = imcrop(imbin, boundingBox); %crop the number plate area
im = bwareaopen(~im, 500); %remove some object if it width is too long or too small than 500
[h, w] = size(im); %get width
```

Figure 3.8 Pixel removal algorithm

3.2.1.8 Character Segmentation

Because all subsequent phases rely on segmentation, it is one of the most crucial stages in number plate recognition. The bounding box approach is the best answer for this situation. The bounding box is built over each character and number on the number plate, and each letter and number are separated for number plate identification. Furthermore, this step will divide each character into a bounding box, which will be compared to the character in the template file. The number of letters for each character will then be generated and read one by one, line by line, if the number plate is a double line kind

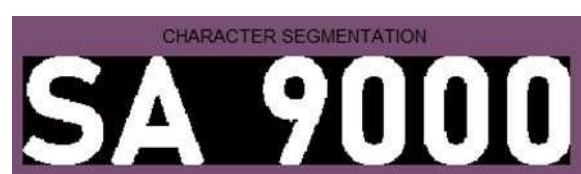
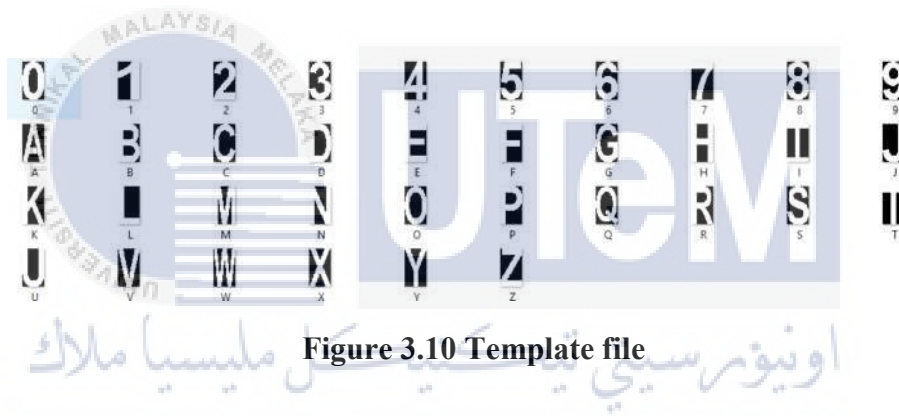


Figure 3.9 Output of character segmentation

3.2.1.9 Character Recognition

The final phase in this system is character recognition. In this phase, the input image will be recognizing the character with the template file and compare with template file for process performed on with given image as input. Template matched will be to extract and resize the letter and character with same size of template file (24x42) pixels and then converted into the text form. In Template file, the 36 character including the number form '0' to '9' and letter from 'A' to 'Z' was created.



3.2.1.10 Software

This section demonstrates how to use MATLAB to implement a number plate recognition system (R2013a). MATLAB is a powerful computer tool that may be used to complete tasks that need a large amount of computing. In comparison to C and C+, it makes algorithm execution easier and faster. The most notable feature of MATLAB is its extensive library capability for image processing and data analysis. As a result, MATLAB is an ideal tool for quickly implementing and validating any method. Debugging problems may be a very difficult chore at times. Aside from that, MATLAB has a lot of cool features like workspace, plot, imread, imhist, imshow, and so on. It is a much better, a higher, a better

alternative than other programs like C and C++ for information investigation and picture processing.

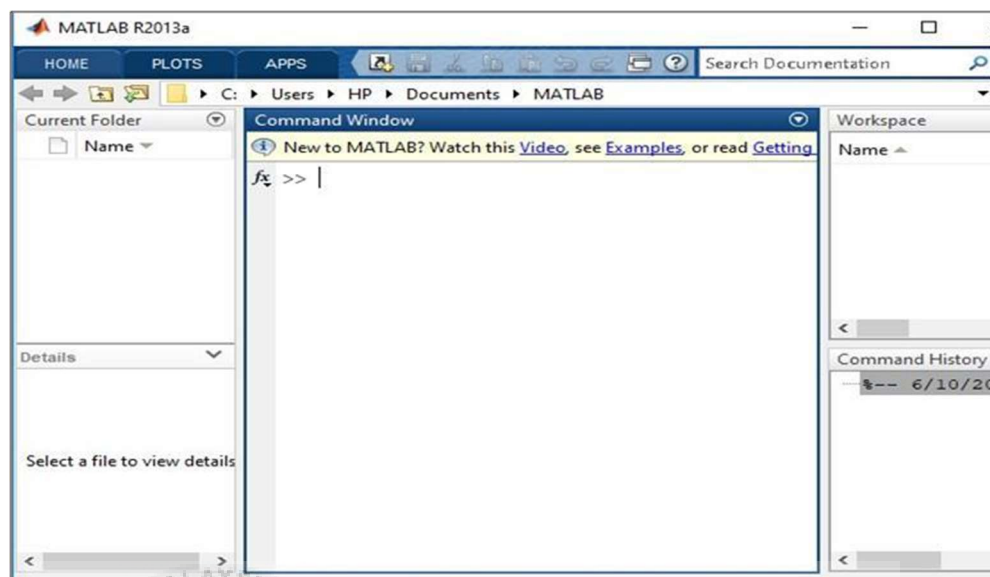


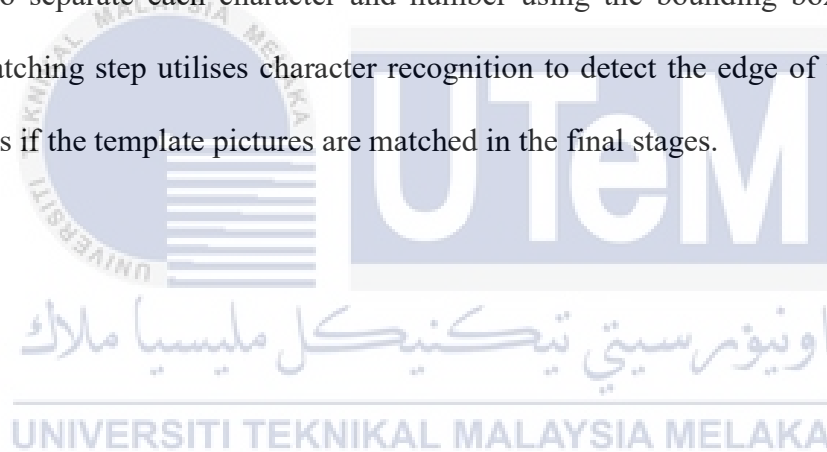
Figure 3.11 MATLAB software interface

3.2.1.11 Gantt Chart

Several inputs are required at this stage of project planning, including conceptual proposals project times table and resource requirements/limitations. Setting the scope of a venture and going through each level of subordinate tasks, errands, milestones, and due dates are the first steps in venture planning. Furthermore, venture planning may be defined as a method of defining how to complete a project within a specific time frame, usually with defined stages and assets. All this data is organized into a Gantt chart, which serves as a project diagram for all parties involved. Gantt charts are useful for planning how long a project should take and for organizing an event or exercise by setting it out to prioritize which tasks should be completed first.

3.3 Summary

We will be able to identify each process for our project at the end of this chapter, and we will utilise MATLAB software to generate the output for this project. For the number plate recognition technology to work effectively, three critical stages must be accomplished. The phases are NPL (number plate localization), CS (character segmentation), and CR (character recognition) (CR). To begin, the input image will be captured with a digital camera. Color photographs will be converted to grayscale photos during pre-processing to improve image quality. During plate localization, the Sobel edge detector is utilised to determine the number plate character. Following that, character segmentation procedures are performed to separate each character and number using the bounding box method. The template matching step utilises character recognition to detect the edge of the photos and then assesses if the template pictures are matched in the final stages.



CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter discuss about the result analysis and all the experiment results are recorded and explain in detail in this chapter and evaluate the NPRS program performance based on all processed involved. This chapter briefly explain about the result of the experiment that presenting the accuracy, performance and effectiveness of this algorithm based on standard benchmarking to recognize the local number plates.

4.2 Application of Graphical User Interface (GUI)

The interface was created to make the experiment process easier and more visible by running it through the GUI rather than running the test one by one using the algorithm.



Figure 4.1 GUI Applications

The GUI application used in this system is demonstrated in figure above. The load plate image file button is the first function on the control panel. This button is used to navigate to and load a number plate image from its source. When you press the load button, a pop-up window will open, asking you to select an image. Once it pressed, it executed the process to

generate the output image. The plate number picture will display in the MATLAB command window if it recognises the plate number that we loaded previously.

4.3 Algorithm Performance

The result of this system based on the last phase output which is character recognition. At this final phase, character segmentation will have compared into template file then it will be matching the character with template files. Others, in character recognition phase the image output from character segmentation will be extract and resize the letter and character. For example, the output from character segmentation is equal with templates file it will be show the result of the character is considered successful. But, if it's not match each other, the character recognition considered failed and will be shown the wrong output.

Template matching method is used for matching the template image for process performed on with given image as input. In Template file, the 36-character including the number form '0' to '9' and letter from 'A' to 'Z' was created. After character recognition, the image will be converting into text form and then matching this number plate with database to checked about the vehicle weather registered or not registered.



Figure 4.2 Perfect Result

To achieve a perfect output, all segmented characters must meet the following criteria each segmented character must be the same size as the character in the template file, which is 24x42 pixels for height and breadth of each character block. Finally, during the segmentation phase, the position of each character in each block must be exact and in the 180-degree position. This is significant because if the segmented character is not in a straight position, the accuracy of the recognition phase may suffer, whereas the character in the template file is in a straight position.

The outcome, as shown in Figure 4.3, is quite poor, with template matching only being able to recognise four accurate characters out of the five segmented characters. The initial image was 50NNY, but once all the steps were completed, the output was S0NNY. This is because some characters had character criteria flaws, such as failing to fit into the precise size of the box of template size (24x42), where the height and width of each character in each block did not match the template file, causing the resulting character to appear cut because its size was larger than the size of the template box. As a result, if the template displayed does not match each of the characters based on the segmentation character result, the result will be incorrect.



اونيورسيتي تيكنيكل مليسيا ملاك


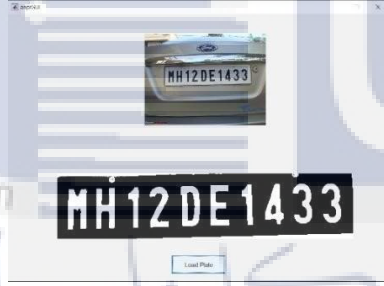
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Figure 4.3 Failed Results

4.4 Algorithm Accuracy

Table 4.4 Sample Plate Number




No	Original Plate	Process Image	Output
1.			<p>Command Window</p> <pre> plateNumber = 'MH12DE1433' </pre>

2.			<p>Command Window</p> <pre>plateNumber = 'RJ19CJ4036'</pre>
3.			<p>Command Window</p> <pre>plateNumber = 'FAWH310'</pre>

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4.			<p>Command Window</p> <pre> plateNumber = 'AXZ016' </pre>
5.			<p>Command Window</p> <pre> // aprGUI plateNumber = 'AP09BN7886' </pre>



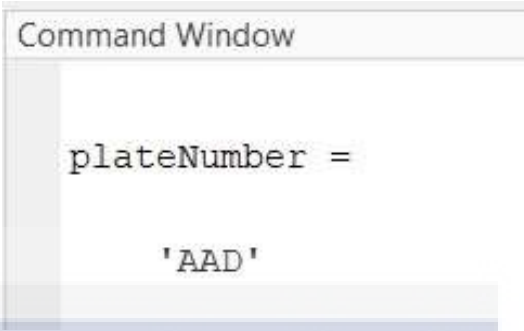

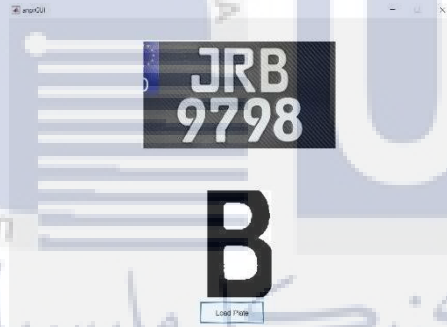
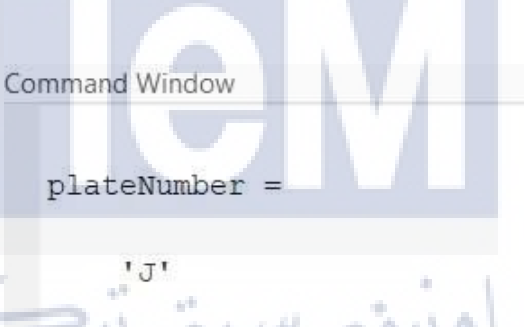
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6.			<p>Command Window</p> <pre>plateNumber = 'KA19P8488'</pre>
7.			<p>Command Window</p> <pre>plateNumber = 'MH14DT8831'</pre>

8.			<p>Command Window</p> <pre> plateNumber = 'UP16CB7145' </pre>
9.			<p>Command Window</p> <pre> plateNumber = 'HR26DK8344' </pre>

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10.			<p>Command Window</p> <pre>plateNumber = 'SONNY'</pre>
11.			<p>Command Window</p> <pre>plateNumber = 'P8'</pre>

12.			
13.			

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The sample photos of 13 sample plate numbers are presented in the table above to assess the algorithm's performance by calculating the system's accuracy. The RGB image, median filtering, erosion, dilation, thresholding, plate complement, pixel removal, character segmentation, and character identification are among the nine steps of plate recognition in this system. The accuracies will be calculated for the entire testing image, which must complete all stages and then be converted into text form successfully. Photographs have been successfully recognised based on the results of ten sample plate numbers in the testing image, while three images have failed. Because each of the characters in segmentation is equal to the Template matching database file in the recognition stage, the 7 photos were successfully recognised with ease. Each character will be divided blob by blob and trimmed to size (24x42) pixel in the segmentation step, after which each character will be compared to the template matching database file in size (24x42) pixel. After all characters have been successfully compared, the picture character will be converted to text form.

After comparing blob by blob by each character in the segmentation stage, six photos were failed to recognise because the segmentation characters are larger than and do not match the database characters in the template file (24x42) pixel. The accuracy of this system will be straightforward to calculate based on the results. The algorithm accuracy of 7 photos successfully recognised out of 13 sample images was calculated using the formula below.

$$\text{Successful Accuracy} = \frac{\text{Plate Number of Correct Recognition Output}}{\text{Input Data}} \times 100\% \text{ Total}$$

$$= \frac{7}{13} \times 100\%$$

$$= 53.85 \%$$

Table 4.5: Accuracy of comparison method with related work



CONCLUSION AND FUTURE WORK

5.1 Conclusion

This section examines the future work and suggestions as a feature of the instrument level later if the task to be improved with the end goal to demonstrate the finding were more positive and accurate, and it also examines the future work and suggestions as a feature of the instrument level later if the task to be improved with the end goal to demonstrate the finding were more positive and accurate. This part is divided into two sections the framework's conclusion and future work and recommendations. To conclude, during the development of this project, each phase of the work process will be completed one at a time, using the most appropriate algorithm. Pre-processing, picture localization, characters segmentation, and character identification are the four phases of this project titled "Number Plate Recognition." Following that, the student was able to create this algorithm using Sobel Edge Detection in the plate localization phase, Bounding Box in the character segmentation phase, and Template Matching in the character recognition phase. Furthermore, students were able to create a Graphical User Interface (GUI) using MATLAB software to display details about the cars and make the whole system's operation simple to grasp. The students could then evaluate the algorithm's performance accuracy using a typical benchmarking technique for number plate recognition. The overall accuracy of this system is 90%, and it is appropriate for UTEM to implement this system at the university to handle the scarcity of parking for student cars. After that, it's also simple to spot students who have copied or produced stickers that say they are not registered with the university.

5.2 Future Works

There are many things that can be improved for future work after successfully designing and implementing this research. To begin, students can improve the algorithm by adding a real-time video algorithm, which will allow them to collect plates in real time. After that, students can enhance by creating a graphical user interface (GUI) for real-time process implementation, which displays information about the student such as name, number matrix, time hour, and date of automobile entering faculty FTK campus. Following that, students may create an algorithm that can recognise any sort of number plate from any country, including Malaysia number plates.



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APPENDICES

Gantt Chart Project Development PSM 1

Activity	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Confirm the title														
Study Journal														
Drafting literature review														
Update literature review														
Methodology														
Introduction														
Report Chapter 1-4														
Preparation slide														
Presentation BDP 1														

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Gantt Chart Project Development PSM 2

[illegible]

