Journal of Engineering and Science Research 4 (1): 20-27, 2020
e-ISSN: 2289-7127

DOI: 10.26666/rmp.jesr.2020.1.4

Proposal for Automatic Vehicle Number Plate Recognition System in POLIMAS

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Abstract: Automatic Vehicle Number Plate Recognition (AVNPR) system is an image processing technology in computer vision which captures the image of the vehicle and recognizes its number plate. Currently, the security and management of transportation system becomes an important key in controlled place such as campus area. With an increased number of vehicles, there is a need for vehicle recognition mechanism that is effective, affordable and efficient. The objective of this paper is to propose an efficient automatic vehicle identification system by recognizing the vehicle plate number. The system will be installed at the main entrance of POLIMAS to ensure that only the authorized vehicles can automatically enter the campus area. Once the vehicle is detected by the input sensors, AVNPR system will capture the image of vehicle plate number. An image is then extracted and investigated character segmentation by using optical character recognition (OCR). The method used for detection of a plate number is by pre-processing of the image and using a combination of Sobel edge detection and Laplacian edge detection techniques. Bounding Box technique is used to find the number plate and character segmentation. For character recognition, OCR method is used by using template matching to compare the segmented image with the template. The system is sustainable as the camera will only be switched on when a car is present. The propose system successfully detects and recognizes the vehicle number plate on real images. This system can also be used for security and traffic control.

Keywords: *Image processing, Vehicle Number Plate, Optical Character Recognition*

1. Introduction

Automatic Vehicle Number Plate Recognition (AVNPR) is a recognized methodology that uses optical character recognition (OCR) on images to read vehicle registration number plates to create vehicle location data. It can be used to store the images captured by the cameras as well as the text from the vehicle number plate, with some configurable to store a photograph of the driver. AVNPR is used by police forces around the world for law enforcement purposes, including checking if a vehicle is registered or licensed. The systems commonly use infrared lighting to allow the camera to take the picture at any time of day or night. This technology must take into account plate variations from place to place [1].

Vehicle's number plate recognition system has been an important area of research interest in image monitoring and processing systems [2]. With the advent of high-tech cameras, AVNPR has numerous applications for traffic management applications, and especially in the parking lot [3][4]. Other applications include border crossing control [5], identification of stolen vehicles [6], automated parking attendant [7], and red light camera [8]. For many of these applications, most of the basic processing algorithms remain the same.

The aim of this project is to develop an AVNPR system that can detect and capture the vehicle image. With the increase of security risk, capturing and extracting number plate can help to reduce human error.

The rest of the paper is organized as follows: section II will discuss about the review of existing system. Section III will present the model system with detailed information on used algorithms. Section IV will end the paper with the conclusion.

2. Literature Review

Automatic vehicle number plate recognition (AVNPR) system in general comprises of three fundamental methods according to Saleem,et. al. [9], G. Balamuruganet. al. [10], and M. V. Srinu, B. S. Shankar [11]. These include vehicle number plate detection, character segmentation, and Optical Character Recognition (OCR). Numerous studies have attempted to explain the methods of an AVNPR system. Many researchers had provided similarly closed methods for this system which consist of few steps for vehicle number plate recognition which are license plate localization, orientation correction,

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brightness normalization, character segmentation and last but not least, optical character recognition [12]. Something closely similar had been reported by Dhruw & Roy [13] which are the steps to identify and extract the image of the number plate. Then extracting the character, recognize and retrieve the vehicle number plate.

2.1 Detection and Capturing of Images

Detection of the number plate is considered crucial to identify the presence of number plate at the entry barrier. One of the most difficult tasks in computer vision and image processing is to detect the object [14]. To detect and capture the image, pre-processing is the technique used to process the image before extraction. For pre-processing, the input of RGB image is converted to grayscale and it is best suited with adaptive binarization methods such as Niblack's method [13].

Pechiammal & Renjith in 2017 reported that using acquisition technique where consideration of the quality of image retrieved by the computer has sufficient light from the camera to get a clear image of the license plate from the car. The accuracy of number plate detection may be challenging due to an open-air environment [15]. A few approaches to be considered are criteria such as the edge of the license plate, texture of pixel intensity distribution and colour character which helps in license or number plates which are tilted or deformed [15].

2.2 Extraction of VehicleNumber Plate

After the detection phase is the extraction of the number plate, in other words, localization of number plates. In the introduction of Kaur & Kaur [16], explained that the number plate extraction phase plays the most crucial role in extracting number plates. Before extracting the largest segmentation, the pixel which is considered noises is removed lesser and a particular segment is extracted and a mask was created [17]. Edge detection algorithm that was proposed by Vikram Mutneja in 2015 include (1) colour of the image is taken, (2) noise is removed as much as possible without causing damages by refining, (3) to intensify its edge, differentiation is applied, (4) to reject noisy edge pixels, edge magnitude threshold is used, (5) application used to estimate edge and spacing between pixels using localization, and (6) after edge exposure the image is to identify. Figure 1 shows the type of edges cited by Vikram Mutneja [18].

There are two categories to classify edge detection method. The first method is gradient based and the second method is Laplacian based [18]. The gradient based edge detection is by taking the first order derivative of the image. The use of the first order derivative of the image function as the maximum and minimum value in the gradient based operation.

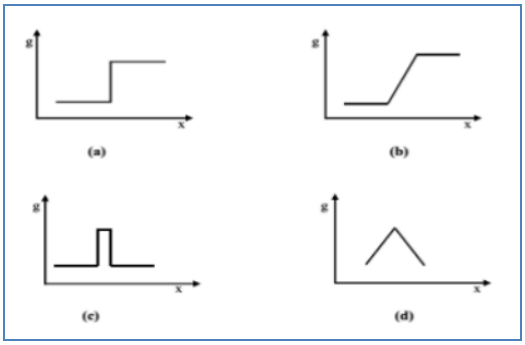


Figure 1: Edge Types (a) Step Edge, (b) Ramp Edge (c) Line Edge (d) Root Edge

Ahn, Lee, Yang, Park, [19] made an improvement on detection of number plate by using Sobel edge operator, Canny edge operator and Laplacian edge operator. As mentioned by them "Sobel edge operator is a representative first order differential operator in the edge extraction technique" and "Canny edge operator is to prevent edges from being improperly calculated due to noise". Canny edge helps to remove noise from the gray scale creating Sobel mask while "Laplacian mask is used to detect contour lines, and Laplacian-Gaussian is used for efficient noise removal".

Kaur & Kaur [16], claimed that there are a few different obstructions that may contribute to the challenges of detection and extractions such as

1. Scene complexity may cause inefficiency in extraction.
2. The location of the number plate is placed differently.
3. Surrounding noise when capturing the image.
4. Noise caused by weather conditions (Rain, Snow)
5. Contrast problem cause by lighting when the image captured.
6. Unrecognizable character, frames and screws.
7. Wrong position on camera or plate causing inefficiency.
8. Poor illumination, reflection and shadow effect on the plate.

These challenges could be improved by enhancing the image using contrast extension and median filtering techniques. Contrast extension was used on the image by applying histogram equalization. After that, median filtering is applied to remove the noise from the image [20]. Cited by IsackBulugu, he suggested an algorithm that was developed to recognize the front and back of the license plate using MATLAB [16]. Another issue reported by Khin, et. al. [21] in recent studies are the angle of detection which then proposed a few methods on skew angle detection. As Kaur&Kaur [16] argued on the challenges of the wrong position of camera and license plates may cause lower efficiency. Khin, et. al., [21] provided the method by identifying certain associated components and fixing the centroids followed by certain algorithm rotates to the correct skew.

2.3 Character Segmentation

Character segmentation would come after extracting the number plate. At this point, the system would have extracted the number plate and then identifying the cropped image is required [17]. According to Beibut, Magzhan, & Chingiz, [22] which work on effective algorithm and method for AVNPR claimed that the segmentation was the group in three subparts while handling with a different format of number plate specifically in the Russia and Kyrgyzstan. Character segmentation at this stage will segment each character and partition them individually [23].

Dhruw& Roy [13] suggested that the bounding box can contribute to character segmentation. The bounding box is using the smallest point which is set in N dimension with all the point lies the minimum in the height and width of each character. To select the best bounding box there must be a contrast in the bounding box, the aspect of the ratio between width and height should be lesser than one to satisfy the property [13].

Figure 2: Number Plate Analyses

Reviewed by Anagnostopoulos [24], in many text recognition systems, projections were used for character segmentation by getting the binary image. The overview is to obtain a vector by summing up the image at columns and row. Sharma, Kumar & Kumar [25] pointed out that there may be some downfall of character segmentation in real time situation because the speed is too quick to detect each character. String recognition is used on number plate images. Figure 2 shows the analysis in the binary object as claimed by Anagnostopoulos [24].

2.4 Character Recognition

The last step in AVNPR is character recognition after segmenting the characters. Different methods provide different ways and algorithms which may vary from various types of number plates. Grayscale is the image received after segmentation. Jain & Sharma [26] pointed out that OCR reader consists of two types which are online and offline. Online OCR is always active in character recognition while offline mode could recognize character recognition all texts at a time.

According to Saleem,et. al., [9], OCR method follows the rule of eigenvectors. Character recognition was the technique that was applied to this method. Previous research highlighted an impact of OCR where it has a longer delay due to each template image stored to recognize characters. Another technique by Kakani, et. al., [27] were using i novel which uses a special character called segments. Finding a segment from other directions and making a particular character unique in a one-dimensional vector can save the projection. In recent studies of Zarei & Shooshtari [28] a new feature vector for OCR which is putting together the orientation of each pixel to a base point by sequence generating. Character set are then used for training the OCR.

Another OCR is based on template matching. This is a technique which is using the compare portions of images against one another according to Firdaus Zakaria & Suandi in 2010 [29]. It has two parts which are feature based matching and template based matching. Statically, 85% of character recognition rate is achieved by using feature extraction method.

2.5 Challenges and Improvements

Other issues that could contribute to AVNPR are low resolution of videos. Mallikarachchi and Dharmaratne in 2014 claimed that image processing has many different techniques in restoring license plate number in low quality videos. The methods are frequency domain methods which include computational and not costly, non-uniform interpolation based super-resolution method is used but not enough to represent the scenario practically and statistical interfacing based super-resolution approaches is the highlight because it is usable in real time. Premasiri, Wijesinghe, &Perera [30] who focused on FPGA real-time AVNPR claimed that to provide faster processing, character recognition and other issues should be in hardware descriptive language. Unlike other authors, Tran and Nguyen [31] have created an Android application called Mobile International Number Plate Recognition which uses computer and mobile phone as the hardware.

3. Methodology

The AVNPR for vehicle recognition is separated into two features; hardware and software configurations. Hardware configuration is the combination of a prototype and a single board computer (SBC). The hardware is integrated with the software. Two different approaches are carried out in this project. The first approach is connecting the software directly to the camera to ensure that simulation could work. Once it successfully carried out, the second approach is integrating SBC with the prototype and software. Software configuration is the method used to capture the image of the number plate and process it through mathematical formulae using MATLAB tool. There are two stages of the method used in the software which are the extraction of a number plate and segmentation, and recognition of characters.

3.1 Hardware Configuration

This will be done on a Raspberry Pi 2 B+ board. The system will be using a camera to capture image when an infrared sensor (IR) senses the presence of a car at the surrounding. The image is then passed through to MATLAB via the board. Detection of the car's presence is done by using an IR sensor and it will then switch ON the camera. The camera that is connecting to the board will capture image of the car. Figure 3 shows the input and output through the Raspberry Pi 2 B+ board. The IR sensor and camera are the inputs to the board while the output is the extraction and recognition of number plate characters.

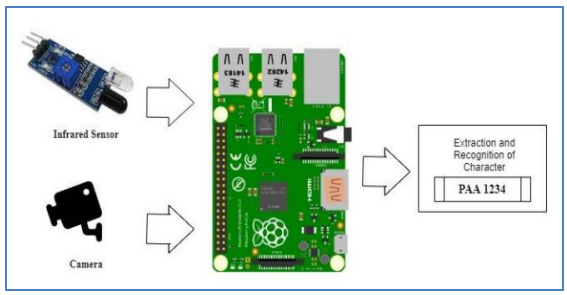
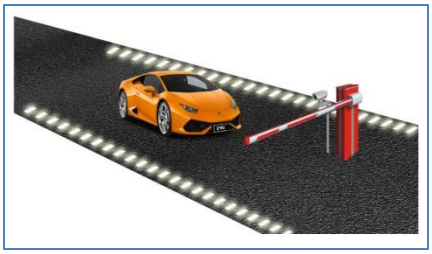


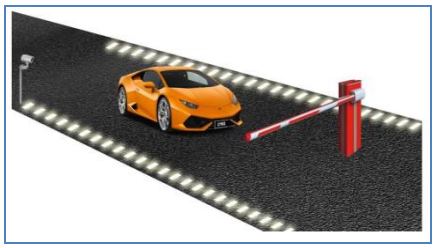
Figure 3: Diagram of AVNPR System

Installation of the camera is a crucial step as it changes due to the surrounding and location that is being installed. Many challenges such as the position of the sun shine or when it is too dark is taken into account. Following are the four major positions that are being considered.

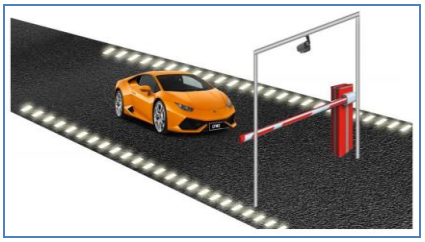
i. Figure 4(a) shows a camera is set up near the boom barrier. The height and distance of the vehicle from boom barrier will be analyzed to provide an accurate reading of number plate. The challenge is that an image taken by the camera will be slightly skewed.
ii. Figure 4(b) shows the camera is placed behind the vehicle. This is to mainly capture the image of the back of number plate. The height of a camera and the distance for a camera from the vehicle is to be analyzed. The challenge is placing the camera behind might be confusing and an image taken by a camera will be slightly skewed.
iii. Figure 4(c) shows the camera is placed in front of the car and boom barrier with a gantry to support it. The height of the poll needs to be measured as well as the distance from the boom barrier to ensure that a camera is able to capture number plate of the car. The image captured will be straight but the height will be a challenge.
iv. Figure 4(d) shows a camera is placed rear of the car with a gantry to support it. The height of the poll and the distance from the vehicle shall be analyzed and measure to be able to get the best accuracy when the number plate is read.



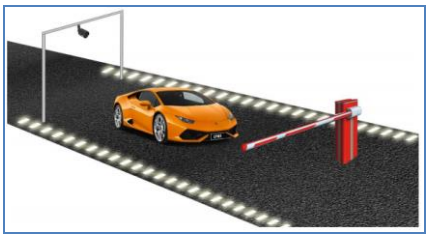
(a) Front side



(b) Rear Side



(c) Front Top



(d) Rear Top

Figure 4: Four Camera Positions

Figure 5 shows a flowchart of the hardware system. After configure the I/O, the IR sensor will wait for detection of vehicle. If it is detected then a camera will switch on and capture image of the car. It is then saved to be processed for recognition. If vehicle is not detected then it will be on standby until vehicle is detected. Figure 6 shows the layout of the circuit diagram. The IR sensor connected to GPIO 14 for transmitter input is used to sense the present of a car. Two LED lights are connected to GPIO 20 and 21, Green and Red is used to show if it is authorized for entry or access is being denied respectively. Web Camera Logitech c930e is an input at Universal Serial Bus (USB) port.

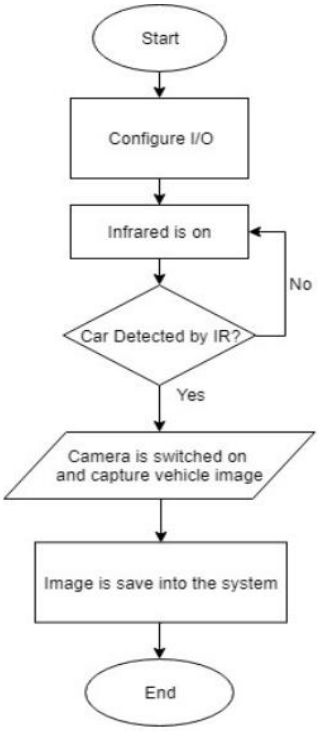


Figure 5: Flowchart of the Controller

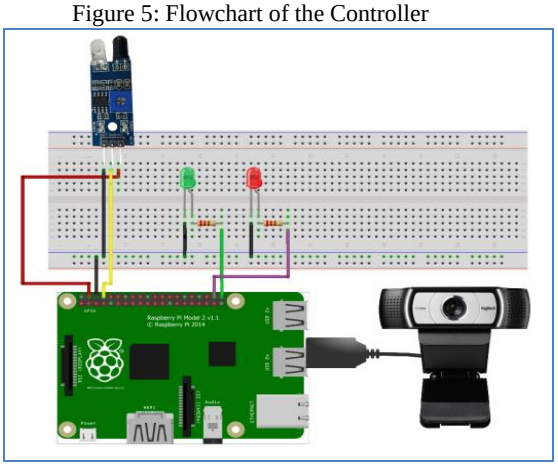


Figure 6: Layout of the Circuit Diagram

3.2 Software Configuration

Software configuration is used for number plate detection and vehicle identification. A simulation on number plates will be carried out to identify each step of a configuration where a certain result is expected to be shown for different techniques that were used by using MATLAB.

3.2.1 Pre-processing of Image

Once an image has been captured, the pre-processing can begin as it is critical in order to continue to the Edge detection phase. The pre-processing consists of converting from RGB to grayscale followed by contrast and intensity adjustments. Removal of RGB is done by eliminating the saturation and hue data of the image. The RGB image comprises 30% of red, 60% of green and 11% of blue. Equation (1) is used for converting RGB to grayscale (Layolin, Angelin, & Chennai, 2014).

Grayscale = 0.2090*R + 0.5870* G + 0.1140*B (1)

The intensity and contrast are adjusted to reduce noise of image. Histogram Equalization technique is used to adjust the intensity and helps to improve the image contrast when the value of intensity image is transformed. Huge amount of data detected in grayscale image. The general way of edge detection of the image is through filtering, differentiation and detection which have higher chances of detecting the image.

3.2.2 Extraction of Number Plate

Detection of number plate consists of two methods; detecting rectangular images according to the size of number plate in the image and by comparison if a size matches image of number plate. An edge of image may have a drastic change in the shade of colour and texture which is used to identify the dimensions and objects in image.

i. Edge Detection Technique

Sobel edge operator is a first order differential operator in the edge extraction techniques. Sobel mask in the Sobel operator is usually use distinguish the boundary of objects because the processing is quicker in terms of speed and the extraction gives out thick edge operation. The extraction includes straight, horizontal and diagonal directions. It has an advantage for brightness of the boundary of the character and background. This operator consists of a pair of 3*3 convolution kernels as shown in Figure 7. Gy shows the image of Gx which rotated by 90º.

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

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

GxGy

Figure 7: Convolution Masks for Sobel Operator

Both Gx and Gy can be combined to find the magnitude of the gradient at each point (Equation (2)),

$$|G| = \sqrt{Gx2 + Gy2} \quad (2)$$

The approximation magnitude is given as Equation (3),

$$|G| = |Gx| + |Gy| \quad (3)$$

The angle of orientation of the edge giving rise to spatial gradient as shown in Equation (4),

$$\theta = \arctan(Gy / Gx) \quad (4)$$

Canny Edge operator performs in multi-stage process. The image is first smoothed by Gaussian convolution. Next, 2-D derivative operator used to smoothen and highlight regions of the image. The edge gradient and direction can be determined using the same equation in Sobel operator. Thirdly, non-maximum suppression is applied to remove false response. Then, double threshold to decide for potential edges is performed. Lastly track edge by hysteresis.

The Laplacian of Gaussian (LoG), the second derivative is very responsive to noise and it plays an important role. The rapid intensity change in the Laplacian is usually used for edge detection. Gaussian smoothing filter is still applied to reduce its sensitivity to noise. The operator of 2-D function produces the scalar function (Equation (5).

$$\Delta f(x,y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \quad (5)$$

Zero crossing is found as edges are examined on those pixels on the image which have locally maximum gradient. The zero crossing of the second derivative selected image edges has some threshold. The 2D LoG function centred on zero crossing with Gaussian standard deviation use Equation (6).

$$LoG(x, y) = -1/\pi\sigma^4 [1 - (x^2 + y^2)/2\sigma^2] e^{(x2 + y2)/ 2\sigma 2} \quad (6)$$

The Laplacian edge detector computes the second order derivative mask using only on mask unlike the Sobel operator. The mask used is 2-D convolution kernel.

ii. Combination of Edge Detection Techniques

After convert the image to grayscale, the technique which is introduced will be used as a combination. An operation is processed where both are combined to create a final detection image. There are two combinations taken in this process to identify which one is more suitable for edge detector. A combination of Canny edge and Laplacian edge detector and another would be Sobel edge and Laplacian.

3.2.3 Segmentation and Recognition of Character

Segmentation of character is the isolation of each character on the number plate. This begins with the image being divided into different subparts. The technique used for character segmentation is bounding box **(**Figure 8). The bounding box method is the labeled region enclosed with rectangular boxes followed by the determination of corner coordinates, height and width. Each alphanumerical character is covered in another bounding box. After identifying each character, it is then cropped and sent for segmentation.

Figure 8: Bounding Box Technique

Figure 9: OCR using Eigenvector

After segmentation of character, comes the character recognition step. The goal is by converting an image text to characters. To develop this part, OCR algorithm is used to recognize the number plate. An image that was cropped is now inverted, this is done by all white pixels are inverted to black and all black pixels are inverted to white as shown in Figure 9. The number plate is separated, and OCR is used to compare each character individually according to the alphanumerical database. Correlation method is used to identify each character and the result is stored in a string format.

3.3 System Flowchart

Figure 10 shows the flowchart of entire system. When a vehicle is detected, the camera will switch on and then the image is captured. Once the image is captured, the pre-processing stage is carried out. The image is adjusted according to the certain criteria then detection of number plate. The number plate then undergoes character segmentation followed by character recognition. The number plate is stored and compared with the template from database. The authorization for the number plate is checked; if it is in the database the barrier opens else access is denied.

4. Conclusion

This paper presented the proposed automatic vehicle identification system using vehicle number plate recognition. The AVNPR software of the system uses series of image processing algorithms for number plate recognition and finally identifying the vehicle from the database stored on the PC. This software is written and simulated its algorithms using MATLAB. The SQL database has been used to store different achieved records of vehicles. The hardware used includes Raspberry SBC board, sensors, LEDs and camera. The system performance on real images is evaluated and the results revealed that the AVNPR system can detect and recognize the vehicle using

number plate in different background and can be implemented at the entrance of highly restricted areas. The prototype system can be integrated and applied at the main entrance of POLIMAS.

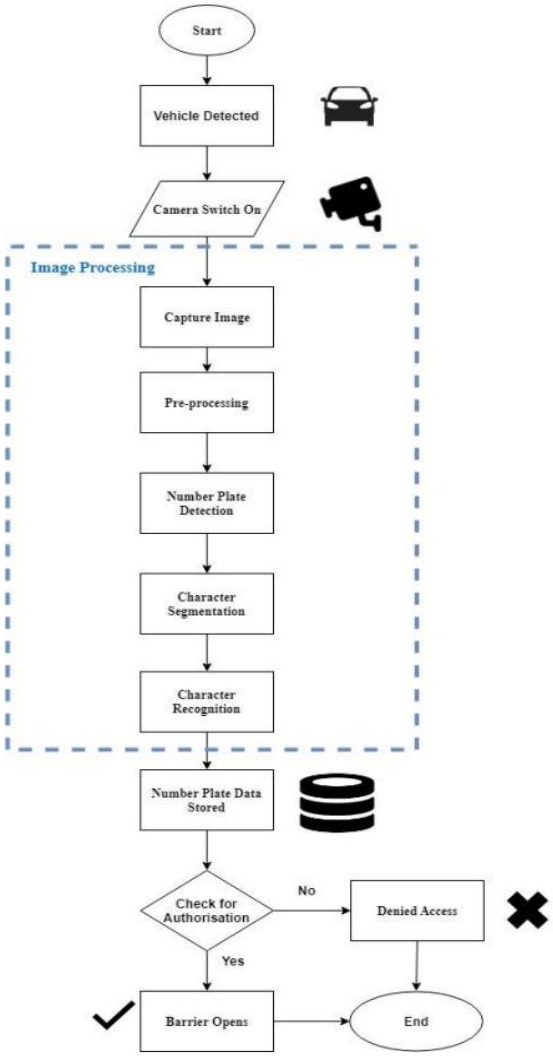


Figure 10: Flowchart of Entire System

Acknowledgement

This projectwas financially supported by the TVET-ARGS(T_ARGS - 91001418) schemeunder the Ministry of Education, Malaysia.

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