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License Plate Number Recognition Using Support Vector Machine (SVM)

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ABSTRACT

Detecting license plates number from vehicle is a modern technology that being use for various purpose such as in traffic application and various security such as control access to enter a car park, find stolen vehicle and gathering traffic flow statistic. However, there is a problem if a user lost their access card, and they are not allowed enter a car park. Due to this problem, it can cause traffic jammed. Besides that, during heavily raining, the barriers gate will be opened to allow staffs, postgraduate students, and visitors to enter the parking lot without scan the access card. Therefore, in this study, license plate number recognition (LPNR) with support vector machine (SVM) is applied. It is used in managing the control access to enter a secure parking lot. The aims of this study are to develop an algorithm for LPNR using multiclass SVM and apply the developed algorithm on a set of number plate images. 26 sets of number plate images will be used in the experimental studies. In developing the algorithm, it consists of seven steps which; input image, pre-processing image, license plate localization, pre-recognition of character segmentation, character enhancement, character recognition and storing recognized image. The experimental processes are successfully applied using MATLAB R2020A. Based on the result, it is shown that 77% license plate number images have been successful being recognized using the developed algorithm. As conclusion, the developed algorithm which is SVM in detect a license plate number of images are applied and plate number being recognized.

Keywords: license plate number, support vector machine, image processing, MATLAB, recognition.

1 INTRODUCTION

Nowadays, automation is very important and beneficial for all of us in every field of modern life. Automation of vehicle number plate recognition has been used for several years in most countries [1]. License Plate Number Recognition System (LPNRS) is a system used for identifying a license plate number of vehicles which registered in database. The technology is based on the image processing where the image of license plate will be captured and processed based on the algorithm developed [2]. This technology can be used in traffic application and various security such as control access to enter a car park, find stolen vehicle and gathering traffic flow statistic. The first Automation Number Plate Recognition (ANPR) has been introduced in 1976 by Police Scientific Development Branch in United Kingdom (UK)[3]. Police departments use ANPR for law enforcement purposes, such as determining whether a vehicle is registered or licensed. License Plate Recognition System (LPRS), automatic vehicle identification, car plate recognition, and optical character recognition (OCR) for cars are some of the other names for ANPR [4]-[5]. Digital image processing is required to recognize a license plate number. It is used to extract useful information from an image in terms of character that appear in license plate number. The image will be captured from camera and convert in gray scale image [6]. The application of digital image processing establishes in various activities which relates in medical image processing, remote sensing, astronomy, and others.

Based on [7], image-processing workstations of the described configuration have various advantages over conventional workstations such as they are relatively inexpensive and contain high performance graphics processors. Furthermore, they are adaptable, reconfigurable, and upgradable. Additionally, the investigator can easily access and use the hardware and software. The image processing is an analyzed and modification of a digitalized image, notably to increase the quality of image processing [8]. The goal of image processing is to change and process an image into a digital form, to produce an enhanced image or to take some of the information used from it. In general, image processing consists of the following three steps: importing the image using tools for image acquisition; output which is the result that can be modified image or report based on image analysis and analyzing and manipulating an image. However, the recent advancements in image processing technology have provided the possibility to develop a system that can recognize a digital image [9].

Based on the system, a barrier gate will be opened if the system recognized the license plate image which the identity of a vehicle has been registered in a database. There are many methods has been used in LPNR such as mathematical morphology, neural network, character segmentation, support vector machine (SVM) and others.

The SVM algorithm is commonly applied in image processing. It can address image and signal processing-related problems such image identification, speech recognition, text classification, face detection, and faulty card detection [10]. [11] assert that, SVM is utilized in structural risk minimization and optimization as well as binary classification to address multi-class problems. Based on [10], SVM is one of the most significance machine learning algorithms that has been applied specifically in the problem of pattern recognition. It is mainly used to classify data of patterns, which the algorithm is used to classify various types of patterns, which are linear and non-linear. The difference between linear and non-linear patterns; linear patterns are easily to differentiate and divides into small dimension while non-linear is difficult to differentiate and divides into small dimensions. It is very important to manipulate and separate an information that obtained from an image. [12] stated that SVM looks for a hyperplane that optimally separates the points of each class. This optimum separation ensures the maximum distance or margin between the hyperplane and its nearest points. These algorithms are commonly known as 'maximum margin classifiers'. The main purpose of SVM is to maximize the margin so that it can correctly classify the given patterns. The bigger margin size, [10].

However, vehicle plate recognition system has a limitation and difficulties to implement in a various place. This is because as plate format itself is different, varies and the uncertainty image condition [13].

Therefore, in this study, the algorithm for license plate recognition will be developed and support vector machine (SVM) will be applied in the developed algorithm to recognize a license plate number.

2 METHODOLOGY

Methodology in this study consist of two stages. There are data collection and algorithm development for license plate number recognition.

2.1 Data Collection

In this stage, it has three processes as shown in the Figure 1.

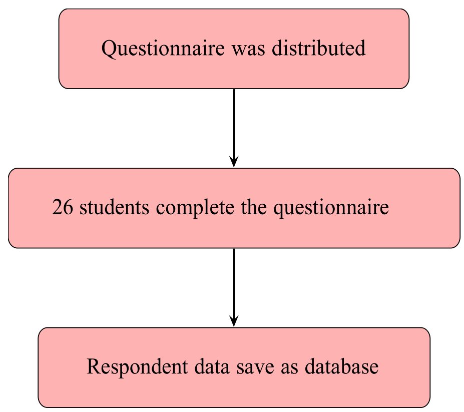
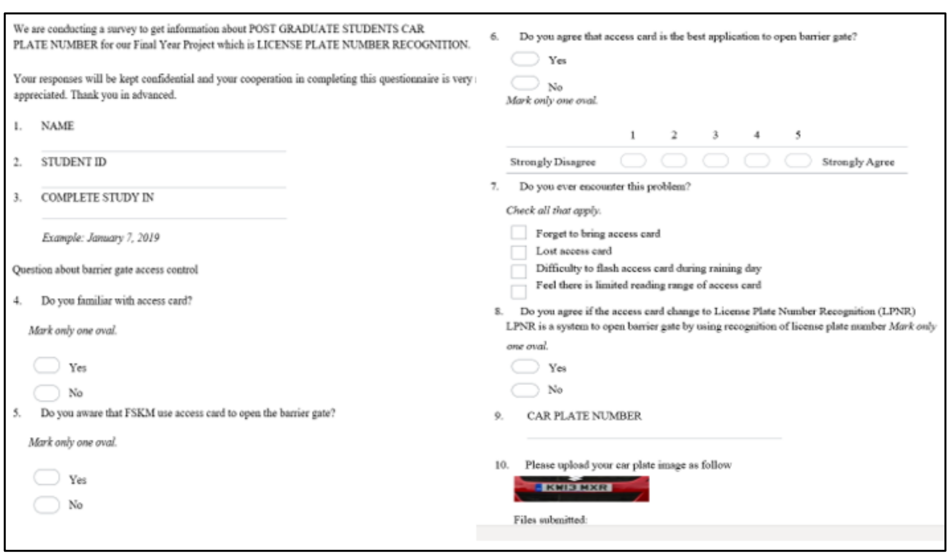


Figure 1 : Flowchart of data collection.

Based on the Figure 1, a set of questionnaires has been set up (Figure 2) and it will be distributed among postgraduate student in Fakulti Sains Komputer dan Matematik (FSKM), UiTM Shah Alam. using online platform which is Google Form via Whatsapp application. The purpose of the questionnaire is to obtain a detail about the students in terms of name, student number and number plate images. It has 26 students from postgraduate in FSKM that have been completed the questionnaire and all the data will be saved in access database.



We are conducting a survey to get information about POST GRADUATE STUDENTS CAR PLATE NUMBER for our Final Year Project which is LICENSE PLATE NUMBER RECOGNITION.

Your responses will be kept confidential and your cooperation in completing this questionnaire is very appreciated. Thank you in advanced.

1. NAME
2. STUDENT ID
3. COMPLETE STUDY IN

   Example: January 7, 2019

Question about barrier gate access control

4. Do you familiar with access card?

   Mark only one oval.

   Yes
   No

5. Do you aware that FSKM use access card to open the barrier gate?

   Mark only one oval.

   Yes
   No

6. Do you agree that access card is the best application to open barrier gate?

   Yes
   No

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree						Strongly Agree

7. Do you ever encounter this problem?

   Check all that apply.

   Forget to bring access card
   Lost access card
   Difficulty to flash access card during raining day
   Feel there is limited reading range of access card

8. Do you agree if the access card change to License Plate Number Recognition (LPNR) LPNR is a system to open barrier gate by using recognition of license plate number *Mark only one oval.*

   Yes
   No

9. CAR PLATE NUMBER
10. Please upload your car plate image as follow

    KM13 MXR

    Files submitted:

Figure 2 : Sample of questionnaire.

2.2 Algorithm Development for License Plate Number Recognition (LPNR)

The algorithm development for LPNR is based on the idea of [14]. In this study, the development consists of seven phases as shown in the Figure 3.

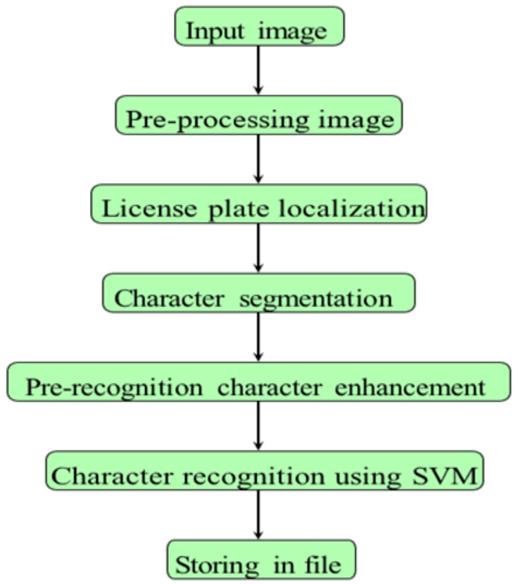


Figure 3 : Flowchart of LPNR.

2.2.1 Input Image

26 images of license plate numbers in .jpg format will be stored in the 'Number Plate Images' files, and binary images of all alphabets and digits will be stored in the 'alphabet' sub-folder. Then, three (3) code in Matlab files have been created in Matlab which are templatecreation.m, letterdetection.m and LPNR.m.

The license plate number image will be read by command im = imread('Number Plate Images/NPI1.jpg') and NPI1 represents the image name. Figure 4 shows the license plate number image that have been read.

Figure 4 : License plate number image.

2.2.2 Pre-processing

The original image will be converted into gray scale image by imgray = rgb2gray(im). Gray scale image is shown in the Figure 5.

Figure 5 : Gray scale image.

Then, binarization by command imbin = imbinarize(imgray) has been applied and binarization image is shown in the Figure 6.

Figure 6 : Binary image.

Based on the template, the change colour of image from black into white and vice versa is needed using command imbin = imcomplement(binarize) and noise is reduced using im1 = medfilt2(imbin,[3 3]). Reduced noise image is shown in the Figure 7.

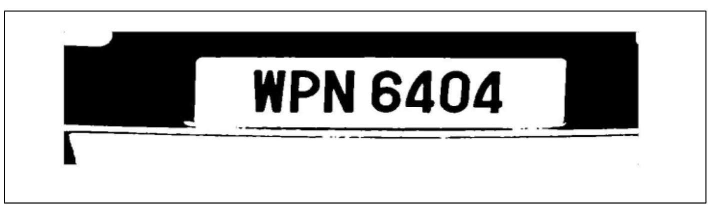


Figure 7 : Reduced noise image.

In this phase, image input for license plate will be converted into gray scale image. The image will be processed to reduce the noise, remove the effect of shadows and remove the low contrast area of an image which performed adaptively. This processed is called as a pre-processing image.

2.2.3 License Plate Localization

In order get the maximum dimension of character, command ***mx = max (max(L))*** is used. The size of every character calculates by ***count = numel (Iprops)***. White pixel density is measured by ***[h, w] = size (im).*** The area is discarded if it is too small or too long than 30 by the command ***im = bwareaopen (im, 30)***. The localization image is highlighted in Figure 8.

Figure 8 : Localization image.

2.2.4 Character Segmentation

The bounding box with green colour is used to segment the character. The command use is:

```
for n=1:size(propied,1)
rectangle('Position',propied(n).BoundingBox,'EdgeColor','g','LineWidth',2)
end
```

The character segmentation is shown in the Figure 9.

Figure 9 : Character segmentation image.

2.2.5 Pre-recognition Character Enhancement

After the character has been segmentized, pre-recognition is required. In this phase, each character will be binarized adaptively and cropped from the center of each character. Enhanced characters by separate the character individually based on the segmentation process. The command is as below:

```
[r,c] = find(L==n);
n1=im(min(r):max(r),min(c):max(c));
```

The single character image is shown in the Figure 10.

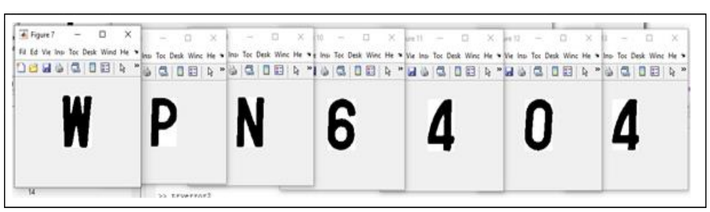


Figure 10 : Single character image.

2.2.6 Character Recognition using SVM

In this phase, each character that has been cropped and binarized will be classified with pre-trained 36 SVMs. Pre-trained 36 SVMs is a set of training data belonging to different classes which are alphabet and number. The alphabet consists of 26 capital letters while the number consists of 10 digits as shown in Figure 11.

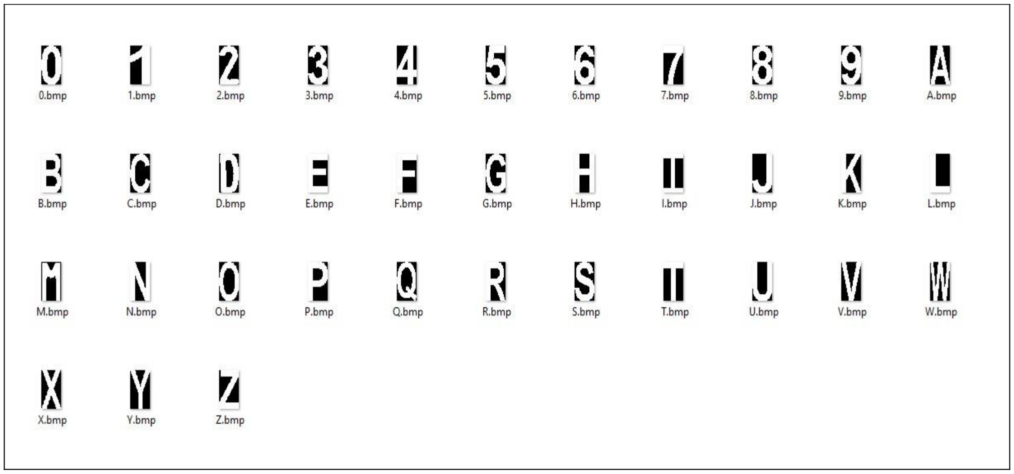


Figure 11 : Pre-trained 36 SVMs image.

Each character trained and classified to one of the predefined classes by checking its position and identifying which class is the best fit for each character.

The training and classification processes are done by using linear kernel Support Vector Machine (SVM) classifier. A binary classification of character be used in SVM elementary form. Then the training data of character is use in the calculation. The SVM calculation is as follow [15]:

$$y = w_0 + w_1 x_1 + w_2 x_2 + \cdots + w_n x_n = w_0 + \sum_{n=1}^{m=36} w_n x_n = w_0 + w^T X \qquad (1)$$

where

m = total training number of plate number
w = the input plate number
x = training number of plate number
n = the input sequence
T = total of the sequence
X = total of the training number of plate number

Consider as 3 hyperplane:

$$w_0 + w^T X = -1$$
$$w_0 + w^T X = 0 \qquad (2)$$
$$w_0 + w^T X = 1$$

If the image is

$$(w_0 + w^T X) \geq 1 - \alpha_n \qquad (3)$$

where $\alpha =$ parameter.

The image is correctly classified when $\alpha_n = 0$, while if $\alpha_n > 0$ it is incorrectly classified. The average error is $\frac{1}{n}\sum_n \alpha_n$ which can be described with the addition of equation $\arg\min \frac{|\vec{w}|^2}{2}$ and the equation as follow:

$$\min \frac{|\vec{w}|^2}{2} + \frac{1}{n}\sum_n \alpha_n \qquad (4)$$

For

$$(w_0 + w^T X) \geq 1 - \alpha_n \qquad (5)$$

2.2.7 Storing in File

After undergoing all the phases above, characters on license plate number that have been recognized will be stored in text file.

The plate number is stored using ***noPlate=[ ]*** command and save in log.txt.

fid = fopen(‘log.txt’, ‘at’);

fprintf(fid,’NumberPlate:fprintf(fid,’———————————————’);

The stored plate number in text file is shown in Figure 12.

```
------------------------------------
Number Plate:-WPN 6404
```

Figure 12 : Text file.

3 RESULTS AND DISCUSSION

The finding of the questionnaire is based on five questions with 26 respondents from the postgraduate student's FSKM. The result shown in the Figures 13, 14, 15, 16 and 17 respectively.

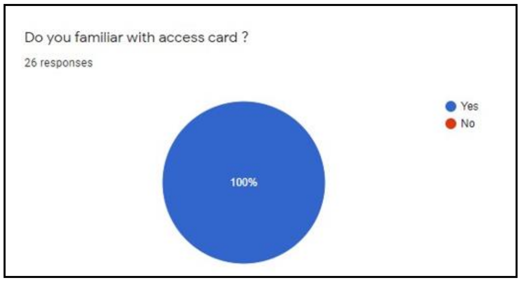


Figure 13 : Question 1.

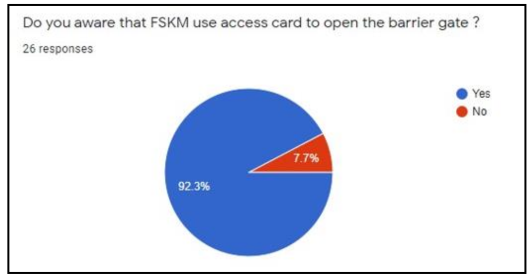


Figure 14 : Question 2.

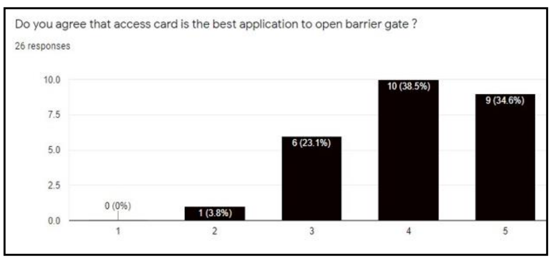


Figure 15 : Question 3.

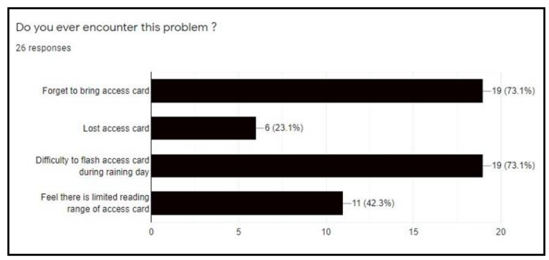


Figure 16 : Question 4.

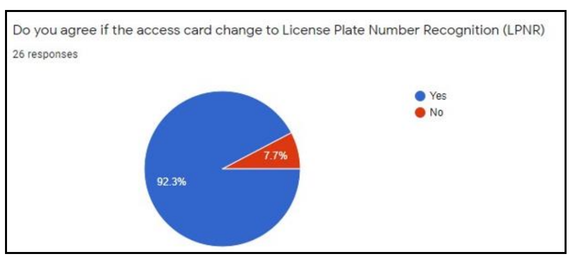
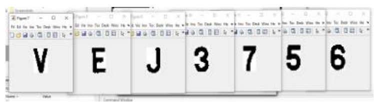
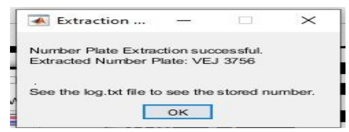


Figure 17 : Question 5.

Based on the Figure 13, it illustrated that 100% respondents are familiar with the access card application. In the Figure 14, it is represented that 92.3% of respondent aware that FSKM use access card to get access through the barrier gate. While other 7% respondents are not aware that FSKM use access card. In the Figure 15, it is illustrated that the respondent's perception whether an access card is the best medium to open barrier gate. Based on the graph above, it is shown that 38.5% respondents were agreed, 34.6% respondents strongly agreed that access card is the best medium to use for entering automated gated parking. There were 23.1% respondents fair and 3.8% disagree about the access card but no respondent does not trust an access card as a best medium to enter a gated parking area. In the Figure 16, it is described the chosen answer by the respondent on the problem they encounter when using access card. 73% respondents answer that they often forgot to bring access card and face difficulty to flash access card during rainy day while it has six respondents ever experienced the loss of access card because of their carelessness. As conclusion, it was found that majority of the respondents which is 92.3% agree if access card changed to LPNR.

The algorithm has been tested for 26 license plate number images. Table 1 shows the result of the LPNR and extraction of the license plate number.

Table 1 : Result of license plate number extraction

Input image	Single character image	License plate number extraction
		
		
		

In the Table 1, it is shown the original image of license plate number, single character of license plate number and dialog box message for plate number extraction. Table 2 below shows the analysis performance of LPNR in terms of license plate number detection, character segmentation and character recognition criteria.

Table 2 : Analysis performance

Criteria	License plate number detection	Character segmentation	Character recognition
Number of tested image	26	26	26
Number of succeeded image	23	22	20
Percentage of succeeded	88%	84%	77%

Based on the analysis in Table 2, it has been tested on 26 images of license plate number. It is shown that 88% have been succeeded to detect the license plate number, 84% have been succeeded to segmentized the character of license plate number and 77% have been succeeded to recognize the license plate number.

4 CONCLUSION

As conclusion, the objectives of this study have been achieved. The algorithm for LPNR has been developed using SVM which based on linear kernel. The developed algorithm in detect a license plate number of images are applied and plate number being recognized. There were 23 license plate number correctly can be detected out of 26 images make the percent 88%. There is 84% of character that being segment perfectly. However, only 20 (77%) license number plate recognized. The rest cannot be detected and recognized because of noise, broken license plate number, and the way of license plate number image being captured. Other than that, 2 row of license plate number also difficult to recognize. All these factors really effect to recognise the license plate number. In future work, it is recommended to find way to eliminate the problem so that the license plate number recognition percentage will be higher and more accurate.

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