Development of Online Vehicle Plate Recognition System

N. Sulaiman[1], A. F. Razali[1], M. S. Jadin[2], A. Abdul Hadi[1], M. Mustafa[1], and K. H. Ghazali[1]
[1]Applied Electronics & Computer Engineering (AppECE),
[2]Sustainable Energy & Power Electronics Research (SuPER),
Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang (UMP), 26600 Pekan, Pahang, Malaysia.
E-mail: kamarul@ump.edu.my[1]

***Abstract*--This document describes the development of online vehicle plate recognition system in Universiti Malaysia Pahang. The system is created to capture image of the vehicle plate automatically and display the details of the vehicle owner including their name, staff or student ID number and contact number in an online mode. The system consists of the development of the hardware part to capture and process the image of the vehicle plate. Meanwhile, the software development involved the design of the Graphical User Interface (GUI) to identify the owner of the vehicle based on the image of the vehicle plate. The results of the project have shown that the proposed system has a capability to recognize the vehicle plate and the owner of the vehicle at the accuracy of 76%.**

***Index Terms*--Vehicle Plate Recognition, Vehicle Owner, GUI, and Recognition Accuracy**

I. INTRODUCTION

THE recognizer machine becomes interest of researchers in many branches of application technologies including security system and monitoring systems. This system becomes crucial in our daily life because of the unlimited increase of vehicles and transportation systems which make it impossible to be fully managed and monitored by humans with manual operation. Among the applications that really require recognition system are traffic monitoring, tracking stolen cars, managing parking toll, red-light violation enforcement, car park entrance, building entrance and customs checkpoints.

Since the last few decades, the number plate recognition has been developed in the field of security system to detect stolen vehicles and security authorization such as entrance admission, government office and college residential area. However, the limitation of the current system is a real-time vehicle plate recognizer still not widely used in market. For instance, the operation of security system in Universiti Malaysia Pahang is still not efficient and insufficient where they still employ the old version of security checking such as the use of an obsolete vehicle sticker to trigger the guard at the guardhouse to allow the vehicle to enter the university's compound. Thus, it is almost impossible for the security guard to detect and recognize every vehicle entering in and out of the campus for the whole time and meanwhile there are lecturers, students, staffs and even construction workers using the same entrance. Therefore, a development of Online Vehicle Recognition System is proposed to be implemented in Universiti Malaysia Pahang where the system can capture an image of vehicle plate automatically and then perform database matching and finally, identify the authorized vehicle to enter the university's compound.

II. LITERATURE REVIEW

Researchers have invented various methods and systems in detecting vehicle number plate. The first number plate recognition system was invented in 1976 at the Police Scientific Development Branch in the UK [1-3].

Early trial systems were deployed on the A1 road and at the Dart ford Tunnel. However, it did not become widely used until new developments in cheaper and easier to use software were pioneered in 1990 and onward. For last few decades, this branch of technology system has been developed vigorously and many drawbacks from the previous research have been improved. The fundamental of the detection system is the application of optical character recognition (OCR) technique on images to read the characters of the license plates on vehicles [3-6] and this system basically divided into a few different versions where there are offline and online types of system. The offline type of number plate recognition system is not in real time system, where the image of vehicle plate is captured first before it is transferred into the system to be processed. Whereas the online type of number plate recognition system is a real-time processed for the captured image [7, 9-10]. The system is able to capture the image and simultaneously process the image of the vehicle plate. However, both of them have their advantages and disadvantages. The accuracy of the system regardless of the type of the detection system depends on the capability of the system to capture the high quality image of the vehicle plate and the application of image processing technique to analyse the captured image. Several factors that might affect the recognition accuracy are the size of the characters in the number plate, the size of the number plate, the background colour of number plate, light condition, weather condition, type of vehicle and the resolution and position of the camera. In analysing the image of vehicle plate, MATLAB is chosen since it is one of the powerful software and preferable by

researchers to be used to develop the algorithm for image processing [8, 11].

Currently, the researchers have come out with new techniques in solving several issues in vehicle plate recognition system. Siam [11] has constructed a practical prototype system to detect the vehicle license plate number at the entrance of the carpark using the image processing technique of capture image, template matching, Internet Protocol (IP) camera and motion detector. The GUI was developed to display the detected vehicle plate number and the result of the template matching based on the number plate. The drawbacks of the research are the information of the vehicle's owner is not available, and the hardware part is implemented using Internet and not tested for any light condition. Meanwhile, Dhruw et al. [12] have applied the Otsu's algorithm to recognize the non-standard Indian number plates. However, the research focuses merely on the offline analysis of the captured image.

Hence, the project has 2 main objectives. The first objective is to create a high accuracy online vehicle plate recognition system using Raspberry Pi and Raspberry Pi Camera Module. The second objective is to identify the vehicle owner based on the analysis of the image of vehicle plate. The project is developed to be implemented in Universiti Malaysia Pahang's compound in order to enhance the existing security system by monitoring the entrance of the vehicle into Universiti Malaysia Pahang's compound. The system should capable to recognize the authorized and unauthorized vehicle. The remainder of this paper is organized as follows; the methodology section describes the overall process and techniques that were implemented in this project. The results of the proposed system were elaborated and discussed in section results and discussion. Finally, the conclusions section presents the outcome of the project.

III. Materials and Methods

This project involved the development, integration and testing of the hardware and software as described by Fig. 1. The system was tested in 2 conditions; (1) Indoor and (2) Outdoor. This is to inspect the effect of the factor of light in determination of the accuracy of the system.

A. Hardware Development

In developing the hardware part of the project, the Raspberry Pi Model B+ is selected to process the data from the captured image. The device is a credit-card sized computer board that's up and running when a keyboard, mouse, display, PSU and Micro SD card with installed OS are added. In addition, it is a miniature ARM-based PC which can run many of the applications that normally require a desktop computer, like spreadsheets, word-processing and games. In this project, Raspberry Pi Model B+ acts as a central processing unit for the whole system. Fig. 2 shows the Raspberry Pi Model B+ that is used for this project. The product information can be accessed through Raspberry website [13].

This stand-alone hardware can be activated or run using MATLAB software. Besides, this tiny, low-cost, single-board computer with audio and video input/output have a system-on-a-chip to process data which includes an ARM®11 processor running at 700 MHz, 512 MB RAM, and a Video Core IV GPU. In addition, Raspberry Pi provides peripheral connectivity for stereo audio and digital video (1080p) and supports USB and Ethernet.

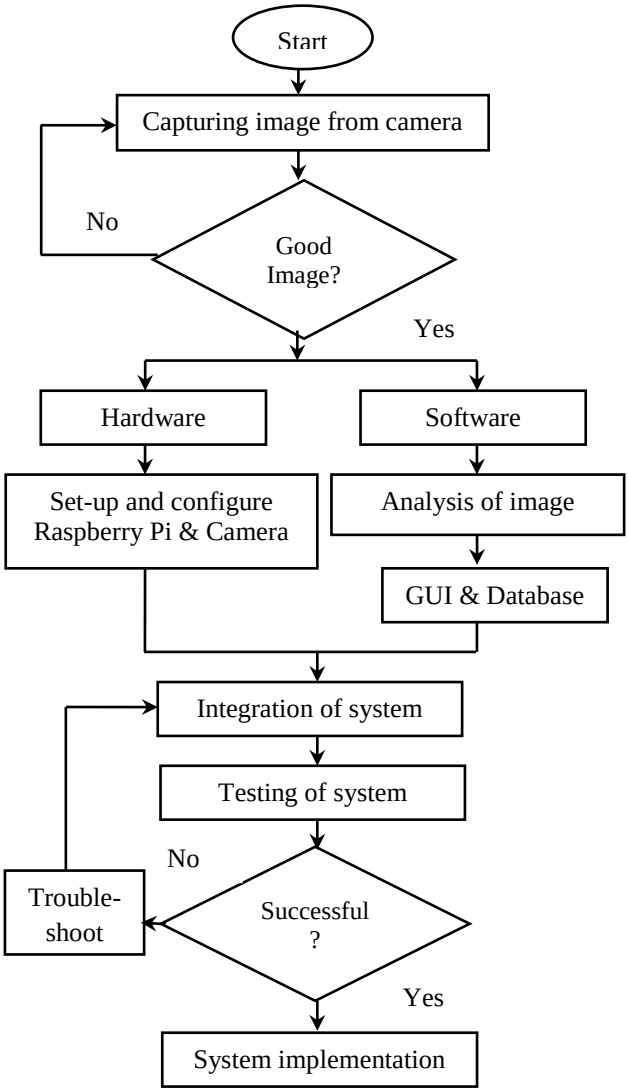

Fig.1. The overall process flow of the project.

Fig. 2. Raspberry Pi-Model B+.

Meanwhile, to capture an image of the vehicle plate,the Raspberry Pi Camera Module can be connected to this device to capture an image of the vehicle plate. It is a high definition camera module compatible with the Raspberry Pi model A and model B. It provides high sensitivity, low crosstalk and low noise image capture in an ultra-small and lightweight design. Here, the camera module is connected to the Raspberry Pi board via the CSI connector which is designed specifically for interfacing with camera. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor. Fig. 3 shows the Raspberry Pi camera module. The project is combined between Raspberry Pi Model B+, Raspberry Pi Camera Module and computer for analysing the image of vehicle plate. The information on Raspberry Pi Camera can be obtained through Raspberry website [13].

Fig. 3. Raspberry Pi Camera Module.

B. Software Development

The development of the software is the most crucial part of the system which includes algorithm, database and programming for GUI and even the efficiency of the system depends on the software used. Therefore, MATLAB R2014 is chosen as the software system for this project to analyse the captured image of vehicle plate. The image processing is implemented using MATLAB image processing toolbox. The analysis process starts from the image acquisition follow by conversion of RGB (colour) image to grayscale image, and then, applying suitable filter and Optical Character Recognition (OCR) technique to the captured image until the character in the vehicle plate can be recognized. In order to remove the noise and to maintain the sharpness of the image, the Laplacian filter is applied to eliminate the noise from the data of the image. The chosen filter is a Mexican-hat filter as depicted by Fig.4. The filter size is 9x9 matrixes. The value of the filter is elucidated by Fig.5. The function of this filter is to detect and highlight the efficient edge without being too sensitive to the noise. By applying this filter to the image of the vehicle number plate, the object will be covered as black and only the line edge of the object will be highlighted as white. The results after applying Laplacian or Mexican-hat filter on one of the image of the vehicle plate are shown in Fig. 6. This figure also includes the effect of applying dilution and erosion in comparison with the application of Laplacian filter.

The MATLAB coding was composed to implement the process of capturing, filtering, inversing, and segmentation of an image of the vehicle plate. Here, the MATLAB coding was also created to record the date and time of the captured image from the data logger to be kept in the database.

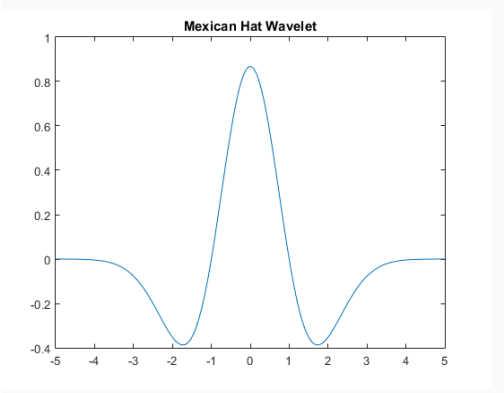

Fig. 4. Example of Mexican-hat filter.

$$\begin{pmatrix} 0 & 0 & 0 & -1 & -1 & -1 & 0 & 0 & 0 \\ 0 & -1 & -1 & -3 & -3 & -3 & -1 & -1 & 0 \\ 0 & -1 & -3 & -3 & -1 & -3 & -3 & -1 & 0 \\ -1 & -3 & -3 & 6 & 13 & 6 & -3 & -3 & -1 \\ -1 & -3 & -1 & 13 & 24 & 13 & -1 & -3 & -1 \\ -1 & -3 & -3 & -6 & 13 & 6 & -3 & -3 & -1 \\ 0 & -1 & -3 & -3 & -1 & -3 & -3 & -1 & 0 \\ 0 & -1 & -1 & -3 & -3 & -3 & -1 & -1 & 0 \\ 0 & 0 & 0 & -1 & -1 & -1 & 0 & 0 & 0 \end{pmatrix}$$

Fig. 5. Parameter of Mexican-hat filter.

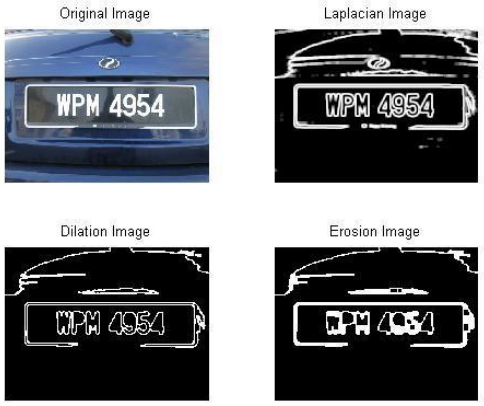

Fig. 6. Application of Laplacian, Dilation and Erosion on the vehicle plate.

GUI then was developed to display the image of the vehicle plate, the results of applying image processing to the captured image, the results of the OCR, identity of the vehicle's owner and finally, the GUI also will display green or red indicator. Green indicator indicates the vehicle's owner is recognized and granted to enter the UMP's compound. Red indicator indicates that the vehicle's owner is not recognized and cannot enter the UMP's compound. The complete set-up of the system is illustrated by Fig.7.

Fig. 7. The complete system set-up.

IV. Results and Discussion

The system was evaluated at 2 conditions; indoor and outdoor. For the indoor testing process, the printed image of the vehicle plate was captured by Raspberry Pi camera inside the laboratory as shown in Fig. 7. Then, the project is conducted by capturing a few images of vehicle plates. The system is tested either it is successful to capture the good image and to recognize the image successfully. 25 samples of image were captured during this testing session. The MATLAB coding to activate the Raspberry Pi and camera is executed first, before the camera can capture the image of the number plate before the data of the image sent to computer for next process. The activation process of Raspberry Pi and to trigger camera to take the picture of the object just require about 10 seconds. Meanwhile, for outdoor testing, the system is set-up as shown in Fig. 8. Here, the system captures the real image of number plate and then process the image simultaneously to recognize the number plate.

Fig. 8. Outdoor testing of the system.

The raspberry camera is placed between the vehicle and computer. Here, there are several things need to be considered during the setup of the experiment. Firstly, the distance between camera and number plate must be approximately 1.5 to 2 meter. Next, another vital factor is the position of the camera to capture the image of number plate. It must be aligned or perpendicular with the position of the plate number of the vehicle. Otherwise, it will affect the resolution of the captured image and disturb the processing of the image in computer. Next, in order to obtain good accuracy, 25 images from 25 vehicle plate were captured during this testing session.

The accuracy of the system is calculated based on the OCR results of the images. The bar chart in Fig.9 shows the accuracy of the system between the indoor testing and the outdoor testing. The accuracy rate is counted using 25 samples of data. For the indoor condition, the successful rate is 60% where the system had successfully recognized 15 vehicle number plates out of 25. Meanwhile, the outdoor case had successfully recognized the number plate for 76% which was 19 out of 25 number plates.

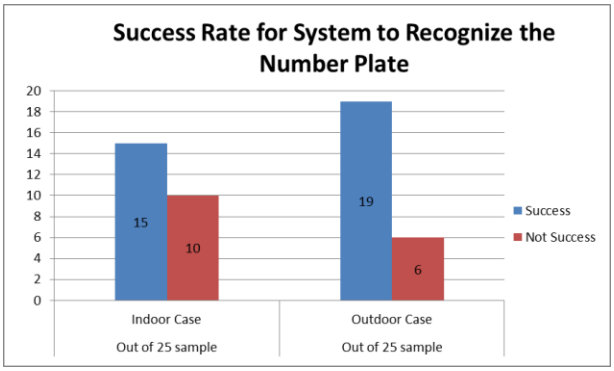

Fig. 9. The system accuracy based the indoor and outdoor condition.

The testing results indicate the factor of the light plays vital role in enhancing the accuracy of detecting vehicle plate number. The detection accuracy is higher at the outdoor condition compared to the indoor condition. These results explain the limitation of the Raspberry Pi Camera Module where the image accuracy and resolution can be affected by the light condition. Besides the testing of the image of the vehicle plate at different conditions, the GUI is developed to display the processing results of the captured image, the results of the OCR, and the identification of the owner of the vehicle.

The picture of the vehicle's owner will be also displayed by the GUI to assist the security guard to recognize the vehicle's owner immediately where the particular of the vehicle's owner can be compared with the employee database of the Universiti Malaysia Pahang. The GUI is tested and run smoothly as depicted by Fig. 10. As displayed in the GUI, after capturing image using the Raspberry Pi Camera, the colour image of vehicle plate will undergo the pre-processing stage where the filtering technique is applied, then, image extraction and segmentation is employed to the filtered image using OCR technique. The recognized vehicle plate number will be automatically written in the Notepad. Next, GUI will display the particular of the vehicle's owner and will indicate 'granted' and authorized to enter the university's compound if those particular of the vehicle's owner matched with the university staff or student database. The overall processing time from the capturing image of the vehicle plate to the recognition of the vehicle's owner might take about 30 to 40 seconds.

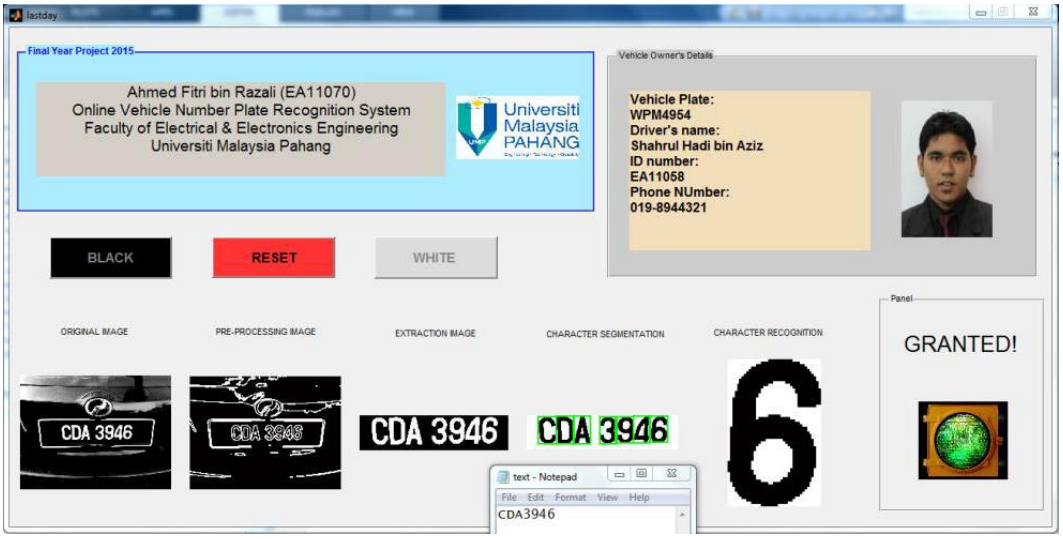

Fig. 10. GUI results.

V. CONCLUSION

The project succeeded in creating online system to detect vehicle plate number with high detection accuracy even though the low resolution of Raspberry Pi camera was used in the detection process. The project also succeeded in creating GUI to display the results of processing the image and identifying the vehicle owner. For the future work, the project will be continued by developing stand-alone system with high resolution camera to capture the vehicle plate regardless the effect of the light such as to capture the image at the night. The use of high resolution camera will improve the quality of the image especially to capture the image at the night. The system will be also connected to the entry gate where the gate only can be opened when the authorized vehicle is recognized. Otherwise, the gate remains close. Another area to improve is to complete the processing time within 10 seconds.

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