Development of Automatic Vehicle Plate Detection System

Norizam Sulaiman
Faculty of Electrical & Electronics Engineering,
Universiti Malaysia Pahang
26600 Pekan, Pahang, Malaysia
norizam@ump.edu.my

Sri Nor Hafidah Mohammad Jalani, Mahfuzah Mustafa, Kamarul Hawari
Faculty of Electrical and Electronics Engineering,
Universiti Malaysia Pahang,
26600 Pekan, Pahang, Malaysia

***Abstract*— This paper presents the development of automatic vehicle plate detection system using image processing technique. The famous name for this system is Automatic Number Plate Recognition (ANPR). Automatic vehicle plate detection system is commonly used in field of safety and security systems especially in car parking area. Beside the safety aspect, this system is applied to monitor road traffic such as the speed of vehicle and identification of the vehicle's owner. This system is designed to assist the authorities in identifying the stolen vehicle not only for car but motorcycle as well. In this system, the Optical Character Recognition (OCR) technique was the prominent technique employed by researchers to analyse image of vehicle plate. The limitation of this technique was the incapability of the technique to convert text or data accurately. Besides, the characters, the background and the size of the vehicle plate are varied from one country to other country. Hence, this project proposes a combination of image processing technique and OCR to obtain the accurate vehicle plate recognition for vehicle in Malaysia. The outcome of this study is the system capable to detect characters and numbers of vehicle plate in different backgrounds (black and white) accurately. This study also involves the development of Graphical User Interface (GUI) to ease user in recognizing the characters and numbers in the vehicle or license plates.**

***Keywords*—** Vehicle plate detection system, image processing technique, Optical Character Recognition

I. INTRODUCTION

Due the increasing number of stolen vehicles from year to year and to assist authorities, researchers had introduced various methods to detect the character and number in plate number of various types of vehicles. Automatic vehicle number plate recognition (ANPR) was invented in 1976 at the Police Scientific Development Branch in United Kingdoms for safety and security. The prototype was implemented in 1979. Automatic vehicle plate detection system was commonly used in parking lot areas and road traffic monitoring system. Here, an image can be obtained from the static object (vehicle at parking area) and moving object (vehicle on the road). Thus, two types of image of vehicle plate can be captured. The details of the vehicle and the owner can be revealed from the image and the owner's database [1].

Among the methods for identifying vehicle plate were Optical Character Recognition (OCR), Radial Basis Function (RBF), Probabilistic Neural Network (PNN) and Fuzzy system. However, OCR was preferable by researchers due to its high accuracy compared to other techniques [2-3]. OCR was used to extract the alphanumeric of plate number from the digital image [2-3]. In this method, an automatic plate recognition system was simulated using MATLAB and tested on real digital image. The result was compared with the characters in database for each alphanumeric character to confirm the plate number. There are several steps to make this system works; detect and capture a vehicle image using USB camera, extract the plate number in an image by applying algorithms or recognition techniques on the selected plate area, apply image segmentation technique to get individual character and finally using OCR application to recognize each characters. However, based on the recent findings by researchers, the major drawback of the OCR technique was due to the high sensitivity of the technique towards misalignment and different size of characters and numbers in the vehicle plate [4, 6].

Beside OCR, some researchers had employed RBF Neural Network to detect and recognize characters especially for Saudi Arabian vehicle plate. The researches applied image processing techniques such as image acquisition, image pre-processing, character segmentation and character recognition on the captured digital image of vehicle plate. Segmentation technique was commonly used in the procedure to extract the character from the plate image after filtering all the distortions such as noise, space mark, light variance and etc. After segmentation, RBF was used in recognition of the character by applying feature extraction technique. The selected method was merely suitable and applicable for Saudi Arabian vehicle's plate since they had unique and complex characters to recognize [4-6].

Since RBF technique just applicable to Saudi Arabian transportation system, researchers had introduced more global technique which was PNN in detecting characters and

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numbers in vehicle plate. PNN was trained to recognize characters using algorithm of image processing and the result were compared with the database. The limitation of this technique was the sensitivity of the technique to the brightness of lights which affects the accuracy of recognizing the characters in the vehicle plate [9].

Fuzzy system was another method used by researchers to extract features from the digital image of vehicle plate. They applied four main modules in searching the location of character and number in vehicle plate. The basic concepts of this technique were colour identification, edge detection, fuzzy maps and fuzzy aggregation. Besides identifying the vehicle plate number, fundamental idea of pre-processing using binary, component labelling and noise removal were employed. The basic method was the character segmentation and the OCR to recognize the characters. They had some common failure of locating module due to the incapability in detecting the boundaries of the vehicle plate number. The failure occurred when the colour of plate is same as body of vehicle. Besides that, the limitation of the technique was the difficulty in differentiating character which might lead to misidentifying characters such as '1' and '7' [7-9]. The summary of the drawbacks of the previous researches on the vehicle plate detection system is illustrated by Table I.

Table I. The drawbacks of methods for detecting vehicle plate

No.	Methods	Drawbacks
1	OCR	Sensitive to misalignment and different size of characters and numbers
2	RBF	Applicable only for Saudi Arabian vehicle plate
3	PNN	Sensitive to brightness of lights
4	Fuzzy	Fail to detect the boundaries of the plate number and differentiating character of '1' and '7'.

Due to the limitations of the previous researches method in recognizing the vehicle plate number, this study is conducted. However, this study is implemented merely to recognize the vehicle plate of non-moving (static) vehicle in Malaysia. The study introduces the application of image processing technique in MATLAB to increase the accuracy of recognizing the characters and numbers in vehicle plate. This is the main objective of this study. The development of the Graphical User Interface for vehicle plate recognition system becomes the second objective of this study.

II. METHODOLOGY

The methodology for this study consists of three major stages. The stages are pre-processing, segmentations and matching process. The pre-processing stage includes the processing of the raw image which is captured by using digital camera until obtaining the specific part of an image. Next step is the segmentations process where the process used for detecting characters on the image of plate number. Finally, matching process is applied to recognize the character from the extracted image with the real characters. The basic process of image processing technique is depicted by block diagram in Fig. 1.

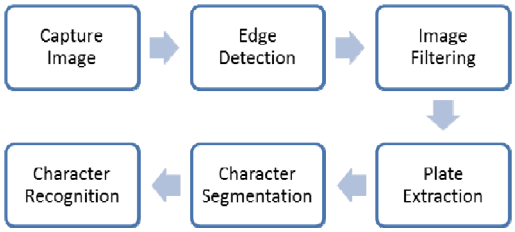

Fig. 1. Block diagram of image processing technique

A. Collection of Image

In this study, 50 samples of image captured using digital camera will be collected and checked for the quality of the samples such as clear image, less disturbance and good view of image. Then, the images were divided into two groups; 35 images of black background of vehicle plate, meanwhile, 15 images of white background of vehicle plate as illustrated by Fig. 2 and Fig. 3. If the image is accepted, the image will be analysed in MATLAB by applying image processing technique. If the image is rejected, a new image will be taken. The process will be continuous until obtaining a good image before proceeding to the next steps. In order to process image, image processing toolbox will be used for pre-processing and filtering image.

Fig. 2. The vehicle plate number with black background

Fig. 3. The vehicle plate number with white background

B. *Pre-processing of Image*

The image originally in RGB format of colour will be converted to black and white format. It will help in identifying the selected region of vehicle plate and minimize the number of colour used in the image. After filtering the image, the plate number will be identified by using segmentation technique. The purpose of this step is to recognize the character of vehicle plate. Some features will be extracted to obtain accurate character recognition. In pre-processing digital image, the colour (RGB) image was converted to gray code first before converting the image into black and white in order to minimize the number of colours used for each image. Next, the black pixel of number plate image will be searched. Then, image will be filtered against noise distortion. In the pre-processing stage, the purpose of applying colour conversion is to reduce the number of range of the colour scale from (0-255) to (0-1). The pixel size of digital image is 640 x 480 pixels.

C. *Filtering of Image*

After converting the colour image to binary image, the filtering technique is implemented to the black and white (BW) images. Mexican Hat filtering is selected to filter and remove noise and distortion on the images. Here, the size of the filter is set to 9 x 9 since size of samples is 640 x 480 as shown in Table II. The Mexican Hat filter was also known as Laplacian of Gaussian (LoG) to a 2-D image or to 3-D volume. The fast implementation was employed. It is a perfect tool to enhance spots, like spherical particles, in noisy images. This module is easy to tune, only by selecting the standard deviations in X, Y and Z directions [8, 12].

Table II. Mexican Filtering

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	-1	-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

D. *Extraction of Image*

Then, an image extraction of vehicle plate is performed to extract the desire features from the filtered image. In order to implement it, the cropping method in MATLAB is empolyed. This method will search for the black pixel of the digital image.

E. *Character Segmentation*

In character segmentation, bounding box technique is applied to detect any characters in the images. Each segment in the plate is counted and represented one by one in the different figure as elucidated by Fig. 4. The template matching in character recognition is applied to recognize each letters in the figure. The method is called OCR. It is the mechanical or electronic conversion of scanned images of handwritten, typewritten or printed text into machine-encoded text [11]. The results are displayed in notepad in term of text as illustrated by Figure 3.7. Meanwhile, Fig. 5 depicts the result of applying OCR.

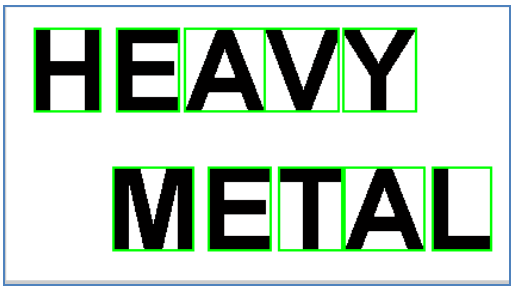

Fig. 4. Example of character segmentation

Fig. 5. Example of character Recognition

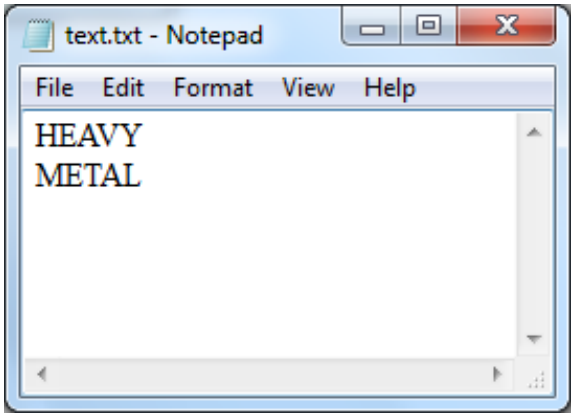

Fig. 6. Result of applying OCR

III. RESULTS & DISCUSSIONS

There are 35 samples of images with black background and 15 samples of images with white background. The location of plate number must be at the middle of the image to avoid errors in image processing and analysis. The results of applying image processing technique to the image of the plate with black and white background are elucidated by Fig. 7 and Fig. 8. In pre-processing stage, the red, green and blue (RGB) colors were converted into binary format to produce black and white (BW) colors only. The conversion was applied to reduce the usage of colors in the image and to make it more clear.

Fig. 7. Color convertion in black background (RBG to BW)

Fig. 8. Color convertion in white background (RBG to BW)

After pre-processing stage, the Mexican Hat filtering was selected to filter and remove noise in the images due to the large dimension of the filters (9 x 9) compared to others filter such as Sobel, Roberts, Canny and Prewitt which has dimension of 3 by 3. The result of applying Mexican Hat filter to the image of vehicle plate with black background is shown in Fig. 9. The results are almost similar to Fig. 7 but more sharper in term of contrast and intensity.

Fig. 9. After applying Mexican Hat Filter

Next, in order to enhance the quality of the image after filtering process, the Morphology operation was applied. The techniques involved 2 processes; opening and closing. Opening used to remove small objects while closing to remove small holes as shown in Fig. 10 and Fig. 11. In this stage, the inverse technique was applied. This process will extract the important features from the image of the plate.

Fig. 10. After applying Inverse Technique

The results of applying image feature extraction are depicted by Fig. 11 and Fig. 12. Here, the value of pixel and size were changed. However, they are a little bit smaller than the actual size. The image processing and analysis algorithms were developed using MATLAB.

Fig. 11. After applying feature extraction

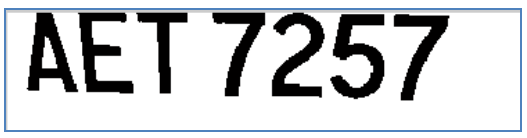

Fig. 12. After applying inversing technique

After applying the feature extraction technique to the image shown in Fig. 11 and Fig. 12, the character segmentation and recognition was performed. The results of these processes are illustrated by Fig. 13 and Fig. 14. In character segmentation, the boundary boxes were built for each characters and numbers. The characters segmentation can detect the boundaries of the black pixel only. The boundary box started counting to the maximum black pixels. As a result, the characters were displayed one by one accurately as shown in Fig. 14.

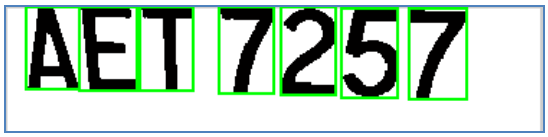

Fig. 13. Character segmentation by applying boundary box

Fig. 14. The results after applying segmentation process

For the final stage of this study, the OCR was applied to the results of the image after segmentation process. It was implemented by employing the template matching as shown in Fig. 13. The template was used to make a comparison between results in characters segmentation and typical letters. The template had alphanumeric which consists of letters A to Z and numbers from 0 to 9. After the successful matching process, the final result was displayed in the text file which can be opened in notepad as shown in Fig. 15.

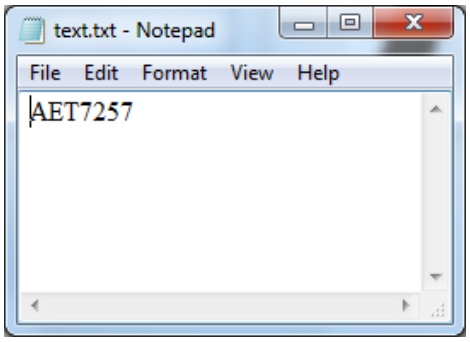

Fig. 15. The results after applying segmentation process

The digital image of vehicle plate was processed successfully and effectively and the results were shown and discussed. Three major techniques such as filtering technique, morphology operations and cropping technique were implemented in processing image. The study was run smoothly in order to achieve the main objective which is to develop an automatic vehicle plate detection system. The minor drawback in this system is the failure of the system to recognize the difference between number '1' and '7'.

A Graphical User Interface (GUI) is developed to implement the process of recognizing vehicle plate where the algorithm for the interface is developed using GUI in MATLAB and the coding for image processing was developed using MATLAB m-file. The example of the GUI is illustrated by Fig. 16 and Fig. 17. Here, various images can be selected from the provided folder, then, by clicking the black button, the image process for the vehicle plate with black background will begin, the same process goes for analysing the vehicle plate with white background. The final number will be shown the provided box and the whole character and number will be written to notepad.

Fig. 16. GUI for black background of vehicle plate

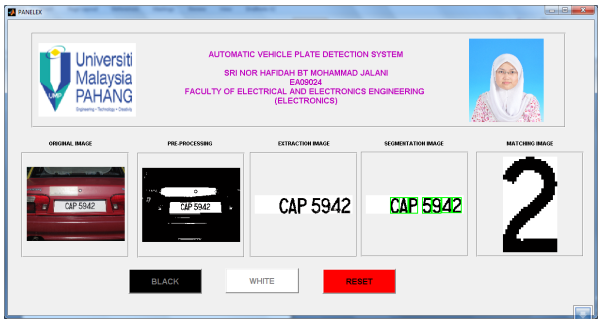

Fig. 17. GUI for white background of vehicle plate

IV. CONCLUSIONS

As a conclusion, a captured image of the non-moving vehicle in Malaysia was chosen as a sample to be used in pre-processing technique in order to recognize the characters of plate number of vehicle. Three main techniques were applied in pre-processing technique. There are cropping technique, filtering technique and morphology technique. The characters and numbers in the image of the vehicle plate are correctly identified. Besides, the GUI is successfully working and displaying necessaries information and results. For the future work, might need to improve the incapability of the system to differentiate number '1' and '7' and also to implement the same process for the moving vehicle including lorry and bus. The stand-alone vehicle plate recognizer will be developed as well.

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