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

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***Abstract*—This paper presents a method for Malaysian car number plate detection system. This method utilizes template matching technique to approximate the location of the number plate region. Using the output from this template matching technique, colour information is used to eliminate the unwanted colour areas from the approximate number plate region without affecting the correct colour regions. Hence, the number plate region can be determined more accurately. This method has low complexity and reduced the processing time magnificently.**

Keywords- template matching; colour information; car number plate; pattern recognition

I. INTRODUCTION

In recent years, demands for intelligent transportation system based on images such as vehicle surveillance, traffic surveillance, etc. are on the rise. Hence, many new algorithms have been produced, especially to detect the car number plate automatically. Despite these many algorithms, differences in rules, shape, font and format for the number plate in a certain country lead to miss detection for some algorithms. As an example, in Malaysia, the number plate can be in two different types; white numbers and letters with black background or vice versa. There are many methods on car number plate detection have been done proposed such as colour features [1], template matching [2], edge information [3][4], morphological operators [5], Hough transform [6], neural network [7][8]. Hough transform needs considerable amount of computing time and a large memory space. An edge-based approach is simple and fast, but it is sensitive to complex background, which sometime caused an increment in false alarm. In this paper, a method based on a combination of template matching and colour information is presented, which combines the colour information method with the output from the template matching algorithm. Malaysian car number plate that contains only two colours makes this algorithm suitable to be applied. As a result, a better detection with minimal processing time has been achieved from this method. The rest of the paper is organized as follows; Section 2 presents a detailed description of the combination method. Section 3 will show the experimental result and finally, conclusion is presented in Section 4.

II. PROPOSED METHOD

A. *Description of Proposed Method*

Fig. 1 shows the block diagram of the proposed method. The input image is first converted to greyscale image, in order to find its intensity information. In order to minimize the processing time, the input image has been cropped, only fifty percent of the lower part of the input image will be processed. This is because, the upper part does not contain a number plate region. After pre processing method has been applied to the image such as top fat filtering, intensity correction, thresholding and median filtering, template matching is applied to the input image to find the number plate region. Then, the output image is once again processed and colour information method will be applied to this image to produce the final output.

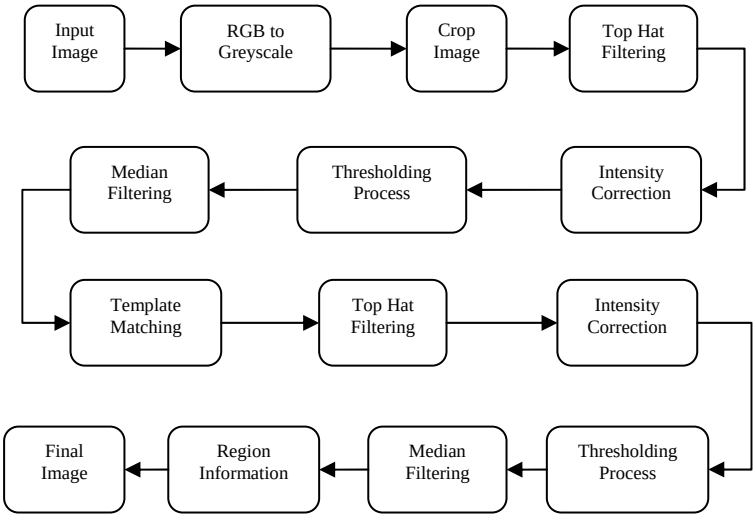


Figure 1. The block diagram of proposed method.

B. *Template Matching*

Template Matching [9] is a technique that compares portions of images against one another. It can be used in manufacturing as a part of quality control [10], a way to navigate a mobile robot [11], or as a way to detect edges in

images [12]. Sample of image may be used to recognize similar objects in the source image. If a standard deviation of the template image in comparison to source image is small enough, template matching may be used. The matching process moves the template image to all possible positions in a larger source image and computes a numerical index that indicates how well the template matches the image in that position. Matching is done on a pixel by pixel basis. In order to have rough detection of the number plate region, we prepare the template size of 166x59 pixels as shown in Fig. 2 and has a random white box pattern that has the element of the number plate region to minimize the false detection. In this paper, template size already been fixed to reduce the processing time. This limitation may lead to inaccurate detection. To correct the uneven illumination of the input image, top hat filtering is applied in order to get the lowest white region without affecting the number plate clarity. Mask of disk shape structuring element with 12 pixels distance from the structuring origin to the point of the disk must be applied to the input image. Table I shows the result of the how the value of the distance parameter affects the output image.

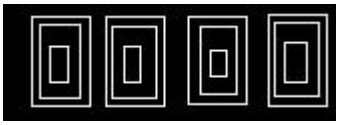


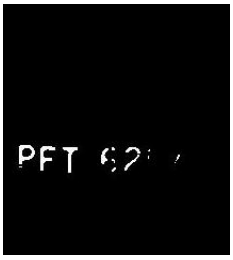
Figure 2. Template used for car number plate detection.

TABLE I. EFFECT OF THE DISTANCE PARAMETER FOR TOP HAT FILTERING

Distance	Output Image
Parameter = 12 pixels	
Parameter = 6 pixels	

From the result shown in Table I, distance parameter 12 pixels produced highest clarity of the number plate region, but we choose a distance parameter = 6 pixels to be implemented in our method. The reason is, in the output image of distance parameter =12 pixels, whole image clarity also been improved but in distance parameter = 6 pixels, only the car number plate region clearer than other parts. According to [1], a good contrast and lighting conditions are important for the number plate detection. For further step, the image intensity needs to be adjusted. The contrast of the image needs to be increased. After increasing the contrast, white region will become clearer than other regions. The white region is assumed as where the number plate look-like region is located. This step is important because it will show the number plate look-like region when converted to binary image. To increase the contrast of the image, intensity value in the grayscale image needs to be mapped to a new value in output such that 1% of data is saturated at low and high intensities of grayscale image. To apply the template to the image, the image is first converted to binary image by converting the input image to the grayscale image and then uses a threshold to convert the grayscale image to be binary. For the number plate detection, threshold=0.95 produces the best results. This is because our database has consistent lighting, which therefore, using normal thresholding for binarization will be the best choice due to its simplicity. To reduce the noise in the binary image, 5x5 median filtering [13] is applied. Median filter considers each pixel in the image in turn and looks at its nearby neighbours to decide whether or not it is representative of its surroundings. It replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighbours into a numerical order and then replacing the pixel being considered with the middle pixel value. Table II shows the output when a difference parameter used for the input image. Image of the distance parameters = 12 pixels produced fewer noise images but the clarity of the number plate region greatly reduced while the image for distance parameter = 6 pixels produce high clarity for number plate region and highest noise level. In our template matching technique, the most important factor is the clarity of the target region, we use a distance parameter = 6. By doing this, we are basically neglecting the noise.

TABLE II. EFFECT OF THE DISTANCE PARAMETER FOR INPUT IMAGE

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

Lastly, to detect the car number plate, template matching technique is applied. This template matching is a process of convolution to compute the full two dimensional convolution between the template and input matrix as in Fig. 3(a). The result of this is depicted in Fig. 3(b).

(a) (b)

Figure 3. (a) Binary image with 5x5 median filtering applied. (b) Template matching method.

(a) (b)

Figure 4. (a) Cross correlation result. (b) Template matching output image.

The central part of the convolution that is the same size as the input matrix will turn as the result. Later, the cross correlation between the template and the region will be computed as shown in Fig. 4(a). The regions which are look-alike will be determined by finding the largest elements in an array in the image as the final result. The coordinate of the number plate region will be recorded for future process. Then, all pixels are values increased except for the number plate region (highest region of the correlation value). The result is as shown in Fig. 4(b). From the Fig. 4(b), we can see that the detection is not really accurate because of the limitation from the fix template size. The number plate region will be the same size of the template, although the real number plate region is bigger or smaller than the template size.

C. Color Information Method

Fig. 5 shows some error detection example using the template matching method. In Fig. 5(a), we can see that the real number plate is bigger than the template size.

(a) (b) (c)

Figure 5. Error detection by template matching method.

This may lead to misdetection because some of the information in the number plate cannot be detected. Figs. 5(b) and 5(c) show that the number plate is smaller than the template size. To overcome the problem between the number plate and template limited size, colour information techniques is applied in this method by using the coordinate and the final output from the template matching method. By assuming the coordinate is the number plate location, the input image is cropped to the coordinates but the size of the coordinates with slight bigger size, i.e. 10 pixels, to overcome the problem where the number plate size is bigger than the template as in Fig. 6(a).

(a) (b)

Figure 6. (a) Cropped input image. (b) Greyscale of the input image.

Similar to the template matching technique, the image is converted to greyscale image as in Fig. 6(b). Top hat filtering is then applied to the input image. Top hat filtering is used to correct the illumination when the background is dark. Fig. 7(a) shows the output of the top hat filtering with parameter is set to 12 pixels. By doing this, the number plate region increased while the background becomes darker. To make the number plate region become clearer, the contrast of the image is adjusted. The result of the modified contrast as shown is Fig. 7(b). According to [1], the number plate region can be obtained by using binary image. To get the binary image, the image threshold value is set to 0.85 (in Matlab) and the median filter sized 5 by 5 is applied to the binary image to eliminate the noises. The output of the binary image as in Fig. 8(a) and the median filtering output as if Fig. 8(b).

(a) (b)

Figure 7. (a) Top hat filtering. (b) Contrast correction.

(a) (b)

Figure 8. (a) Threshold Image. (b) Median Filtering Image.

To obtain the actual number plate coordinate in Fig. 8(b), the top, bottom, right, and left edges of the characters are used. The final result is shown in Fig. 9.

Figure 9. Final Image of proposed image.

III. Result and Discussion

The proposed method is compared to template matching and colour information methods independently in separate experiments. The entire tests are implemented on MATLAB and executed by an AMD Athlon 64, 2GHz, under Window XP environment. The output images have been evaluated using 3 different grades; 'Best' – For accurate detection; rectangular size perfectly matches with the number plate region. 'Good' – For average detection; rectangular does not fit the number plate region perfectly, and 'Not Accepted' – For false detection or the rectangular is too big for the number plate region. The examples of these categories are presented in Fig. 10. Total of 71 samples were used as input images (48 images for front view and 23 images for rear view) where the size of the image is 640 x 480 pixels. All results are shown in Table III, Table IV, and Table V for front view, rear view, and average of front and rear view, respectively. From Table V and Fig. 11, we can see that without using the combination method, the template matching gives high detection in front view 'Good' detection. This algorithm can detect the number plate region in high accuracy but the rectangular cannot locate the number plate location accurately. This is because the rectangular size is equal to the size of the template used in the algorithm. Car number plate region location and size always change in different situation, but the template size is fix, so this may lead to "Good" detection only. The accuracy for this method is 88.7%. Some of the misdetection due to the following reasons:

- Low intensity of the number plate region will produce low matching result.
- Less accurate colour segmentation will affect the correlation value.

Grades	Image
'Best'	
	The rectangular in the output image fit the number plate accurately.
'Good'	
	The rectangular in the output image can detect the number plate but the size of the rectangular does not fit the number plate region.
'Not Accepted'	
	Although the rectangular include the number plate region, but other part of the car also include in the region.
	
	The rectangular fit the number plate region but some of the numbers do not included in the rectangular.
	
	No number plate region detected.

Figure 10. Examples of evaluation grades.

In comparison for 'Best' detection, the colour information gives higher detection in comparison to template matching but on the other hand, also gives high false detection. The accuracy for this method is 66.19%. This low detection result by the algorithm due to the following reasons:

- The car grill or manufacturer logo whiter than the car number plate colour. When the system converts the image to binary, it will detect the grill or the manufacturer logo as the car number plate region.
- Some of the car number plate intensity not in the same level. This will make only a part of the actual car number plate region will be detected by the system
- The crop to edges method to finalize the car number plate location is easily being affected by noise. If noise not totally being eliminate, the noise will be detected as the car number plate region.

TABLE III. FRONT VIEW TEST RESULTS.

Colour Information Method		
'Best'	***'Good'***	***'Not Accepted'***
24	2	22
Accuracy : 26/48 = 54.1%		
Template Matching Method		
'Best'	***'Good'***	***'Not Accepted'***
2	***45***	***1***
Accuracy : 47/48 = 97.9%		
Proposed Method		
'Best'	***'Good'***	***'Not Accepted'***
40	***8***	***0***
Accuracy : 48/48 = 100%		

TABLE IV. REAR VIEW TEST RESULTS.

Colour Information Method		
'Best'	***'Good'***	***'Not Accepted'***
20	1	2
Accuracy : 21/23 = 91.3%		
Template Matching Method		
'Best'	***'Good'***	***'Not Accepted'***
0	16	7
Accuracy : 16/23 = 69.5%		
Proposed Method		
'Best'	***'Good'***	***'Not Accepted'***
18	3	2
Accuracy : 21/23 = 91.3%		

TABLE V. OVERALL TEST RESULTS.

Colour Information Method		
'Best'	***'Good'***	***'Not Accepted'***
44	3	24
Accuracy : 47/71 = 66.19%		
Template Matching Method		
'Best'	***'Good'***	***'Not Accepted'***
2	61	8
Accuracy : 63/71 = 88.7%		
Proposed Method		
'Best'	***'Good'***	***'Not Accepted'***
58	11	2
Accuracy : 69/71 = 97.1%		

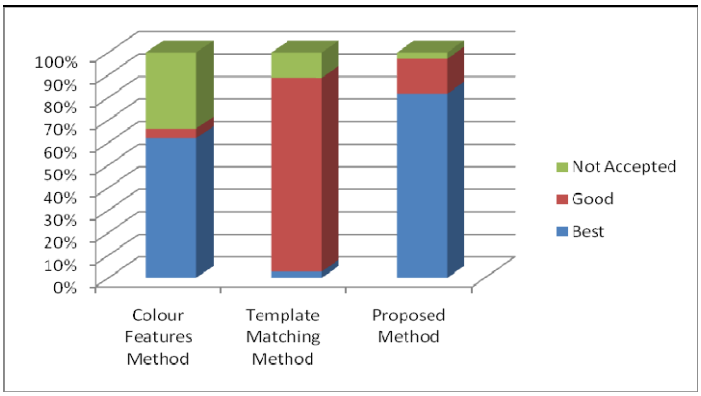


Figure 11. Overall Test Result.

After implementing the proposed method, the result improved to 97.1%, compared to 66.19% using colour information, and 88.7% using template matching. The detection grade of the proposed method resulting majority in 'Best' detection. From these results, we can conclude that proposed method performed better than the colour information and template matching while giving 'Best' grade of detection and high accuracy detection. The 'Not Accepted' results from the proposed method due to the following reason:

- Inaccurate coordinate pass by the template matching algorithm.

Fig. 12 depicts the false or inaccurate detection for colour information and template matching methods, but the problem does not occur in proposed method. The proposed method achieved a high degree of detection, indicating that the results are more appropriate for real application.

IV. ACKNOWLEDGMENT

This work is supported by USM Short Term Research Grant 304/PELECT/6035270.

V. CONCLUSION

A simple but yet efficient method to detect Malaysia car number plate has been presented in this paper. The proposed method normally utilizes template matching and colour information to perform the detection. It exhibits at least comparable / better detection results than utilizing only template matching or colour features method. For future work, we will further improve the detection process in terms of time and accuracy so that it can be implemented in real-time application. On top of that, we will also include character segmentation and recognition processes into the system as the main goal of the project is to develop a secured intelligent car parking management system.

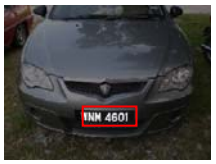
Colour Information	Template Matching	Proposed Method
		
Error detection because of the manufacturer logo. The rectangular size is too big although the car number plate region included in the detection.	The car number plate region can be detected but the rectangular size is bigger than the actual number plate region.	The car number plate region can be detected acurately using the proposed method.
		
Error detection because of the car grill. The rectangular size is too big although the car number plate region included in the detection.	The car number plate region can be detected but the rectangular size is bigger than the actual number plate region.	The car number plate region can be detected acurately using the proposed method.
		
Error detection because the algorithm failed to detect the car number plate region.	The car number plate region can be detected but the rectangular does not include all the number plate region.	The car number plate region can be detected acurately using the proposed method.
		
Error detection because of the car grill. The rectangular size is too big although the car number plate region included in the detection.	The car number plate region can be detected but the rectangular size is bigger than the actual number plate region.	The car number plate region can be detected acurately using the proposed method.

Figure 12. Optimization result observed in proposed method.

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