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Study on Traffic Sign Recognition

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Abstract: *Traffic sign recognition can help the driver to make a right decision at the right time for safe driving. The realization of traffic sign recognition system usually divided into two stages: detection and classification, This paper presented an algorithm for detection of traffic sign using convert region of interest (ROI) polygon to region mask method. The algorithm detects the traffic sign from the images captured from different environment and different position angle. The proposed method extracted the detected sign in black and white pixels and further classified into groups. In this paper introduces the main difficulties in road sign recognition with further discussion on the potential trend of road sign recognition.*

Keywords: *Traffic sign recognition, detection, binarization, classification, region of interest (ROI).*

1. INTRODUCTION

In recent years, vehicle driving has become common in the everyday life. Hence, the accelerating process of modernization and the increasing of car ownership, road traffic safety have become crucial especially in the development countries such as Malaysia and Singapore. In fact, there are considerable amount of the people lose their lives due to traffic accidents in every year. One of the major factors contributes to the traffic accident is failure to detect the traffic sign boards during driving time. Recently, many researches focus on the traffic sign identification area.

Traffic sign can improve the traffic flow and provide safety for the drivers. Traffic sign detection and recognition are widely experimented due to the wide application used in the intelligent vehicles as driver’s support system. Several applications have been developed focused on the traffic sign area such as alert system of the potential danger, navigation and driving safety. Examples of such a system include adaptive cruise control, lane departure warning system, collision avoidance system, night vision, traffic sign recognition, and etc [1].

1.1. Sign Description

Traffic sign contains a lot of important information about current traffic environment. Traffic signs are designed to regulate flow of the vehicles, indicate the danger and difficulties around the drivers, issue warnings and assist driver in the navigation. The two basic types of traffic signs are namely ideogram-based and text-based. The ideogram-based used ideograph to express the sign meaning and the text-based contains texts, arrows and symbols. Most existing research focuses on the ideogram-based traffic signs. The most essential types of traffic signs used in Malaysia are prohibition, warning, obligation and informative. Figure 1(a), (b), (c) and (d) show the example of traffic signs of prohibition, warning, obligation and informative types respectively.


Figure 1(a): *No Entry* **Figure 1(b):** *Slippery Road*


Figure 1(c): *Keep Right* **Figure 1(d):** *Petrol Station*

2. LITERATURE REVIEWS

The first research on traffic sign recognition can be traced back to 1987; Akatsuka and Imai [2] attempted to make an early traffic sign recognition system. A system capable of automatic recognition of traffic sign could be used as assistance for drivers, alerting them about the presence of some specific sign (e.g. a one-way street) or some risky situation (e.g. driving at a higher speed than the maximum speed allowed). It also can be used to provide the autonomous unmanned some specific-designed signs. Generally, the procedure of a traffic sign recognition system can be roughly divided of two stages namely detection and classification.

2.1 Detection

The goal of traffic sign detection is to locate the regions of interest (ROI) in which a traffic sign is more likely to be found and verify the hypotheses on the sign's presence. The initial detection phase of a traffic sign recognition system offers high costs due to the large scale of detection in a complete single image. In order to reduce the space, prior information of the sign location is supposed to be cropped [3, 4]. This technique called as ROI. ROI locates the traffic sign in the image based on the shape. The traffic signs are cropped and declared as informative signal. The background image is declared as unwanted signal and removed by defining as black pixel. By these assumptions, a large portion of the image can be ignored. Traffic signs are designed with particular color and shape which make them easier to be recognized.

The detection of traffic signs using only a single frame image has some problems: 1) it is difficult to correctly detect a traffic signs when temporary occlusion occurs; and 2) the correctness of traffic signs is hard to verify. To increase the speed and accuracy of traffic sign detection in subsequent images by using information about the preceding images, such as the number of the traffic signs and their predicted sizes and positions, can be used. Moreover, information supplied by later images is used to assist in verifying the correct detection of traffic signs, and in this way those detected and tracked traffic sign can reduce the burden of the processor.

2.2 Classification

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze [5]. A binary image classification method is a digital image that has only two possible values for each pixel. The pixels used to represent the object and background is white and black respectively. Based on classification process, the technique used in the classification of traffic sign is binary classification method. Each traffic signs is grouped based on the amount of white and black pixel. These amounts are matched with the amount of white and black pixel from the template data.

3. METHODOLOGY

Traffic sign recognition algorithm using image processing technique has been developed by combining several methods such as binarization, ROI and pixel matching. Binarization is an early process applied to the traffic sign image. The binarization method ensure the image is in good condition before the implementation of ROI technique.

3.1. Binarization

At the first stage, all images are transformed from RGB color space into black and white color space. Hence, the red regions of each image are detected by the black and white saturation values of pixels. Figure 2 shows the converted image from RGB (Red, Green, and Blue) color into the black and white pixels by using image processing toolbox.

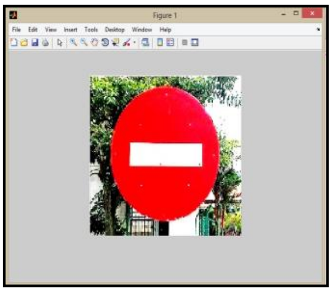


Figure 2(a)

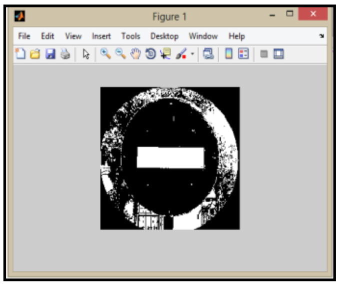


Figure 2(b)

Figure 2: *RGB to binary image conversion.*

3.2 Region of interest (ROI) method

Region of interest (ROI) method locates the traffic sign in the image frame. Using ROI method, large portion of the image can be ignored by declaring other pixel as background. Circle shape traffic sign is the most common shape used in traffic symbol. Therefore, circle shape is been the first sign for preliminary reduction of the search space, followed by the geometrical edge and corner. The algorithm of ROI is formulated as equation 1.

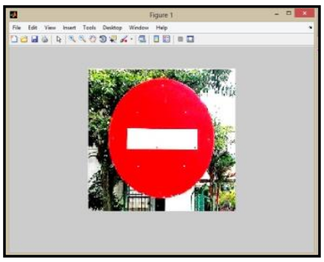
ROI = poly2mask(r*cos (t) +c (1), r*sin (t) +c (2)   equation 1

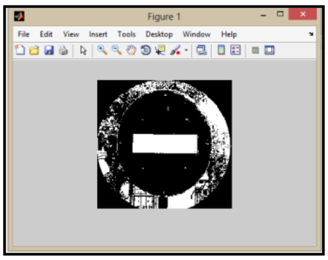
t = Approximate circle with 50 points

r = radius

c = [X axis, Y axis]

Figure 3 shows the different level of circle shape of ROI based on various radius of the circle. Figure 3(a), (b) and (c) show the original image of no entry sign, circle cropped method with 70 points and circle cropped method with 100 points respectively. The cropped circle is converted from RGB to binary image.





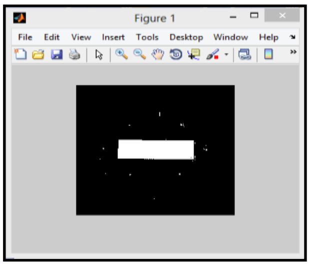


Figure 3(a): *No entry sign* **(b):** *ROI with 70 points* **(c):** *ROI with 100 points*

3.3. Pixel Classification Method

Image segmentation is typically used to classify objects or relevant information into several groups. Focusing on project's purpose, white and black pixels are assigned to different regions based on their intensity values. Each pixel in the similar group contains of similar pixel's intensity. Based on the classification method, the total amount of pixel is been calculated separately and matched with the pixel's total amount in the template database. Different values in total amount of pixel indicate different traffic sign images. Algorithm for pixel's classification is shown as follow:

1) Amount of black pixel = Sum (Sum (Image==0));
2) Amount of white pixel = Sum (Sum (Image));
3) Total amount of pixel = Rows*Columns
4) Percentage of black pixel = 100.0* amount of black pixel / Total amount of pixel
5) Percentage of white pixel = 100.0* amount of white pixel / Total amount of pixel

4. Results and Discussions

The results are shown in percentage unit referring to the percentage of detection white and black pixels from the traffic sign image. The percentages of white and black pixels are matched with the template traffic sign from database. Figure 4 shows the example of percentage output. The matched traffic sign from the database is identified and displayed to users.

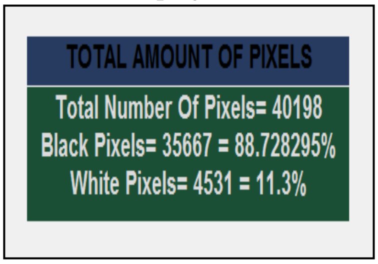


Figure 4: *Detection of pixels percentages*

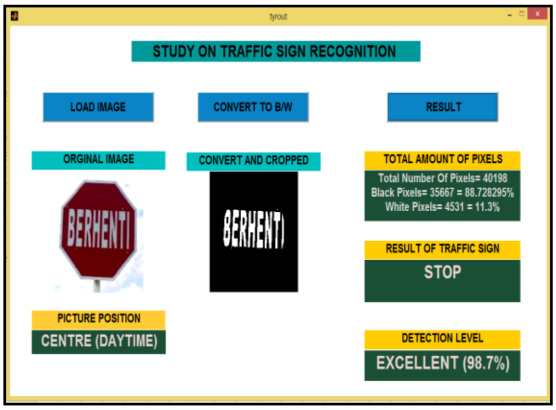


Figure 5(a): *"BERHENTI" traffic sign*

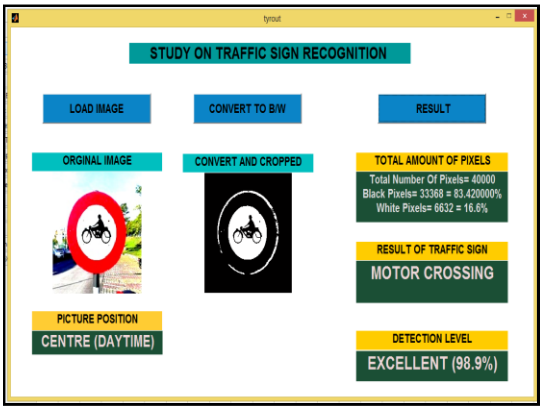


Figure 5(b): *"MOTOR CROSSING" traffic sign*

Figure 5: *Example of output system*

Figure 5 shows the example of system's output. The output displays the result of traffic sign identified from the database. Detection level of percentage has been measured for accuracy of the detection. The level of percentage values has been separated into several groups namely "No detection", "Poor detection", "Average detection", "Good Detection" and "Excellent detection" as shown as Table 1.

Table 1. *Accuracy level of detection*

Percentage	Accuracy Group
0 % - 20%	No Detection
20% - 40%	Poor Detection
40% - 60%	Average Detection
60% - 80%	Good Detection
80% - 100%	Excellent Detection

Based on table 1, the accuracy level of detection determines the condition of images captured from the environment. No detection and poor detection levels show the images contain a lot of noises and blur. These noises due to the heavy rain, cloudy and etc. Detection of 60% and above indicates the clear environment. Besides, blocked sign and different angle of sign's capturing also reflect to the good detection, Based on these factors, the result of traffic sign detection as shown as table 2 and figure 6.

Table 2. *Detection of traffic sign based on 3 samples*

TRAFFIC SIGN	ANGLE (^{0})	DAYTIME	BLOCKED	AFTER RAINING	NIGHT	
					ACTUAL PICTURE	AFTER BEAM LIGHT (A.LIGHT)
Motor Crossing	Left (45^0)	95.1%	35%	80%	0%	79%
	Centre	98.9%	80%	95%	0%	87%
	Right (45^0)	94.5%	30%	85%	0%	90%
No Entry	Left (45^0)	88%	22%	22%	0%	51%
	Centre	99.97%	76%	95%	0%	95%
	Right (45^0)	95%	75%	81%	0%	82%
Stop	Left (45^0)	95%	40%	70%	0%	80%
	Centre	98.7%	35%	90%	0%	94%
	Right (45^0)	75%	30%	56%	0%	88%

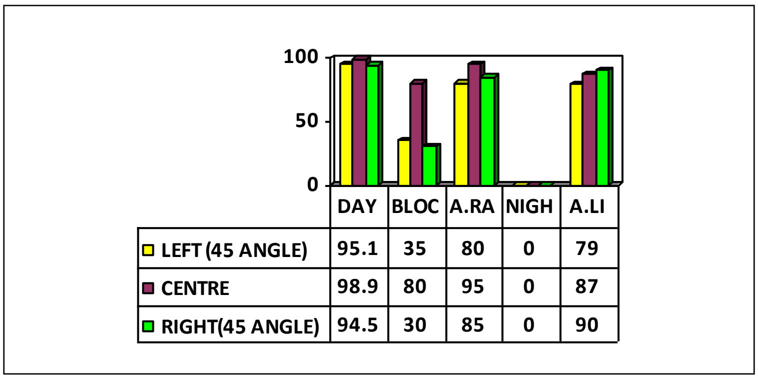


Figure 6(a). *Motor Crossing Detection*

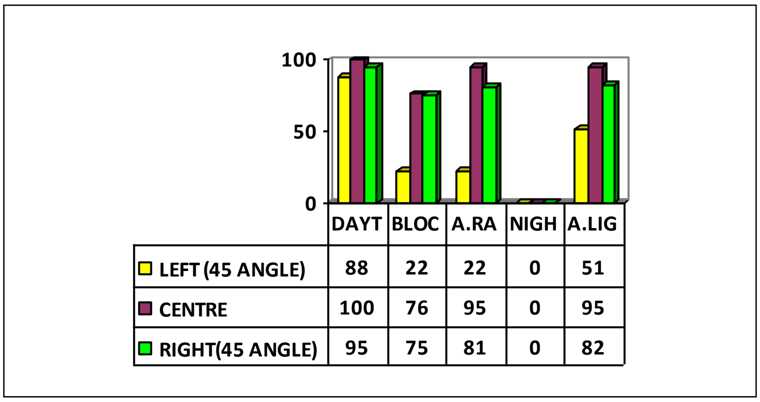
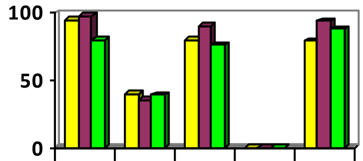


Figure 6(b). *No Entry Sign Board Detection*



	DAYT	BLOC	A.RAI	NIGH	A.LIG
LEFT (45 ANGLE)	95	40	80	0	79
CENTRE	98	35	90	0	94
RIGHT(45 ANGLE)	80	39	76	0	88

Figure 6(c). *Stop Sign Board Detection*

Figure 6(a), (b) and (c) show the detection level of traffic sign under several factor such as angle of image captured, blocked image, clear daytime, after rain and night conditions. The daytime or sunny day detections show higher percentage of accuracy for 3 different sign boards of different angles. The highest and lowest detection in daytime is 99.97% for "No Entry" and 75% for "Stop" sign board respectively. During daytime, the vision is clear and brighter compared to the other situation.

The blocked traffic sign during image capturing shows average detection of different angles. The highest and lowest detection in daytime is 80% for "Motor cross" and 22% for "No entry" sign board respectively. Based on the blocked condition, the sign image is blocked in the middle area of image. As an output of the ROI process, the blocked traffic sign affect the percentage of detection. The blocked image reduces the accuracy of detection in big margin as well as affects the driver to recognize the traffic sign.

The detection after the raining shows good detection for 3 traffic sign under different condition and angles. During the raining time, the environment looks so cloudy and darker compared to daytime. The highest and lowest detection in daytime is 95% for "Motor cross" and "No entry"; and 22% for "No entry" sign board respectively. The detection level percentage is still high due to clear and bright vision after rain. The clear vision helps the detection level reaches the maximum level.

The detection at night time shows poor detection from 3 traffic sign under different situation and angles. During night time, the environments are very dark and the system is unable to detect any present traffic sign. Detection level shows 0% during night time. To solve this program, the traffic sign is captured after the beam light of the car. The highest and lowest detection in daytime is 94% for "Stop" and 51% for "No entry" sign board respectively.

5. Conclusion

The traffic sign recognition is a very helpful driver assistance technique for increasing traffic and driver safety. In this project, low computing complexity, adaptive and accurate mechanisms have been applied to extract and recognize the content of each traffic sign. Several techniques and methods have been implemented to recognize the traffic sign such as binarization, region of interest (ROI) and pixel's classification has been proven successful. The system has been proven to produce high accuracy of detection based on different conditions such as angle of image captured, daytime, night and etc. The experiment shows that the average recognition can achieve until 35% for the blocked traffic sign. The highest accuracy has been detected at 99.9% during daytime. In practice, reliability is the most important factor. However, detection of a traffic sign may involve the same difficulties as object recognition in natural outdoor environments such as lighting conditions are changeable according the weather. The presence of other objects in the scene such as moving cars, bicycles, pedestrians, shop signs also offer obstruction in detection. The long exposure to the sunlight and reaction of the paint fades the color of traffic signs. The images captured from a moving car are also reducing the quality of image due to motion blur and car vibration. For these reasons, the reliable detection of traffic signs from such scenes becomes rather challenging.

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