VEHICLE BRAKE LIGHT DETECTION USING HYBRID COLOR MODEL

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For my beloved family, friends and lectures for helping and supporting me during my studies.

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ABSTRACT

Vehicle brake light detection is an important safety feature that should have in every car in Malaysia. By refer to the statistic of accidents in Malaysia by the Ministry of Transportation Malaysia in 2009 to 2012 is increasing, the total number of road accidents in Malaysia are 341 252, 363 319, 373 071, 397 330, 414 421, 449 040 and 462 423 respectively. Therefore, we propose a project to detect vehicle brake light to reduce number of accident in Malaysia. This project can be applied in intelligent vehicles and able to give an early warning to the driver in the future if someone is breaking ahead. On top of it, this system also can provide safe feeling and confident while driving to the driver. This project is focusing in Melaka region only and four various weather will be considered in image capturing. MATLAB will be used to develop an algorithm to detect vehicle brake light. Furthermore, in order to detect vehicle brake light, a hybrid color model will be applied which consist of combination of red color from RGB color model and method from HSI color model. At the end of this project, we are able to detect the vehicle brake light in 3.32 seconds delay and 83.31% of detection.

ABSTRAK

Pengesanan cahaya brek kenderaan merupakan ciri keselamatan penting yang perlu ada di dalam setiap kereta di Malaysia. Dengan merujuk kepada statistik kemalangan di Malaysia dari Kementerian Pengangkutan Malaysia pada tahun 2009 hingga 2012, bilangan kemalangan jalan raya meningkat di Malaysia iaitu 341 252 , 363 319, 373 071 , 397 330, 414 421, 449 040 dan 462 423. Oleh itu, kami mencadangkan satu projek untuk mengesan cahaya brek kenderaan untuk mengurangkan bilangan kemalangan di Malaysia. Projek ini boleh digunakan di dalam kenderaan pintar dan dapat memberi amaran awal kepada pemandu pada masa akan datang jika seseorang adalah melanggar kenderaan di hadapan. Selain itu, sistem ini juga boleh memberikan rasa selamat dan yakin semasa pemanduan kepada pemandu. Projek ini memberi tumpuan di rantau Melaka sahaja dalam pengambilan sampel gambar dan empat pelbagai cuaca akan dipertimbangkan dalam menangkap imej. MATLAB akan digunakan untuk membangunkan satu algoritma untuk mengesan cahaya brek kenderaan . Tambahan pula , untuk mengesan cahaya brek kenderaan , model warna campuran akan digunakan yang terdiri daripada gabungan warna merah dari RGB model warna dan kaedah dari HSI model warna. Pada akhir projek ini, kita dapat mengesan cahaya brek kenderaan kelewatan 3.32 saat dan 83.31% daripada jumlah pengesanan.

CONTENTS

LIST OF TABLE

LIST OF FIGURES

Chapter I

INTRODUCTION

1.1 Introduction

In automobile industry, safety issue is the most important aspect that needs to be considered for the manufacturer and the designer in designing the vehicle. However, with current safety feature there are still accidents happened and increasing by years. In our opinion, despite of being focus on the safety feature of the material of the vehicles they should focus more on the safety feature of the vehicles system.

There is nothing wrong with the current safety features however something is lacking from the system and need to be upgraded. As a result, many organization and education departments of university have designed driver assistance systems installed in the intelligent vehicles. This is due to people sees the safety feature as a major aspect to be focus and the vehicles manufacturers use safety feature as a major selling point.

Thanks to recent technology which can be used to develop the image processing algorithm to detect color based which is reliable when to detect vehicle brake, traffic light, etc. With this approach, we come up with a project named 'Vehicle Brake Light Detection using Hybrid Color Model'.

In the next section, we will have a view of problem statement, objective of study, scope of work, significant of study and thesis organization.

1.2 Problem Statement

There are quite high numbers of accident in Malaysia. Table 1.1 show the number of drivers involved in road accidents acquires from Polis Diraja Malaysia and also shows that accidents in Malaysia are increasing from 2007 to 2011. The highest number of accidents in Malaysia is in year 2007 which is 26691. One of the causes of the accidents is the attitude or behavior of the driver that does not follow the law while driving. Furthermore, not following safety distance driven by the driver is also one of the causes. The more the distance travelled, the higher the chance to get into an accident because the driver will be tired. Thus, this project is proposed and it also can be applied in an intelligent vehicle in the future to reduce the numbers of accidents in Malaysia.

Table 1.1: Number of drivers involved in road accidents [1]

Type of Vehicles	2007	2008	2009	2010	2011
Total	26691	25274	24960	22527	25570
Bus	73	70	50	46	225
Jeep	229	245	209	235	495
Trailer/Lorry	550	487	455	400	654
Motorcars	3514	3303	3556	3003	4868
Motorcycle	18151	17533	17172	15726	16240
Van	281	241	191	213	364
Bicycle	979	818	785	613	598
Pedestrian	2738	2399	2367	2161	1859
Others	176	178	175	130	267

1.3 Objective of Study

The objectives of this project are:

(a) To detect vehicle brake light by using combination of RGB color model and HSI color model.
(b) To analyze the overall performance of the systems in terms of percentage of detection and time consumption.

1.4 Scope of Work

The scopes of this project are:

(a) MATLAB software will be used to develop the algorithm.
(b) Four weathers will be considered as condition in image capturing which are morning, noon, evening and raining.
(c) Canon Power Shot A2500 16 Megapixels camera will be used to capture the sample images.

1.5 Significant of Study

This project should be able to lead the automotive industry to a better future as it will help the drivers who use the vehicle. The implementation of the project in the intelligent vehicle in the future is the right move because lately there are quite of number growth in intelligent vehicles produced. The purpose of the implementation is to increase the safety feature of the vehicles so that it will aid the driver by giving an alert to the driver when there are people breaking ahead Thus, this project will

help driver in safety driving and help the automobile industry to growth. Therefore, the number of accident in Malaysia can be reduced.

1.6 Thesis Organization

This report consists of five chapters. The summary of each chapter will be explained as follow.

Chapter 1 will describe about introduction of the vehicle brake light detection, problem statement that describe the reason for developing the project, objective of the project, scope of work, significant of study and thesis organization.

Chapter 2 is about review on previous research by other researcher in other countries. Various methods and approaches that related to this project have been discussed and reviewed.

Chapter 3 explains about method that will be used in this project. RGB color model, HSI color model and Otsu's method will be described in this chapter. Segmentation and filtering of sample images also will be carried out in this chapter.

Chapter 4 explains about result of the simulation from the five weathers condition. Next, results will be analyzed and percentage of detection and time consumption will be computed.

Chapter 5 present overall conclusion for the project. Some recommendations or suggestions rises to improve this project also will be discussed in this chapter.

Chapter II

LITERATURE REVIEW

This chapter explains about the background research which related to this project. Brief explanation about the perspective and methods used in the previous research is present in this chapter. We also show how this project is related with the available research and how it is different from the others.

2.1 Previous Research on Vehicle Brake Light Detection

With the current technology available, lots of safety feature installed in the car such as ABS brake system, airbag system and etc. However, when it involved with driving, human beings are still cannot focus ahead while driving and cause to accidents. When it comes to prevention of accidents itself vehicle light detection is the solution because of the automatic detection of these lights can aid in the

prevention of otherwise deadly accidents. In the next section, we will have a view of this method and perspective used in previous research.

2.1.1 Color Model Based Concept

Color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components. When this model is associated with a precise description of how the components are to be interpreted, the resulting set of colors is called color model [10].

Cabani *et al.* proposed color-based detection of vehicle lights as an approach in the conception of a vision system dedicated to the detection of vehicles in reduced visibility conditions. The development of the system which detects vehicle lights consists of five major steps which are transformation RGB to L*a*b*, the choice of L*a*b* color space, rear-lights and rear-brake-lights detection, flashing-light detection and reverse-light and headlight detection. The results of the experiment of this project is tabulated in Table 2.1, performance of vehicle light detection. False detection of white color are often due to reflection of headlights on the road. Non detection of red color correspond to rear lights of far vehicles. False detection of orange color are due to saturation of rear lights in the image [2].

Table 2.1: Performance of Vehicle Lights Detection [2]

Color Detection	white	red	orange
Number of processed images	426	426	236
Total number of lights	660	382	47
Total number of detected lights	631	184	30
False detection	24	2	3

Chen *et al.* proposed an approach that can detect brake lights at night using a camera by analyzing frequency domain. In the approach of brake light detection, in which this researchers aim to detect brake lights of vehicle without need of complete tail of

vehicle in shape. This methods they are using consists of two major stages which are candidate regions detection using YCbCr color model, frequency domain analysis of taillight regions and brake-light detection in frequency domain. The sample image taken is converted from RGB color model to YCbCr color model. Then the luminance channel of YCbCr is used to detecting tail lights. For the result of this project, the sample image captured under different situation is set to 320 x 240 resolution value. The sample image can be separated into two different cases which are one is the condition that one major vehicle appears in front and case two is the condition that multiple major vehicles are present in the camera field of view. The overall detection rate is about 73.7% and details quantitative evaluation of detection rare is shown in Table 2.2 [3].

A year after that, Chen *et al.* also introduced a new approach that can detect brake lights at night by analyzing the taillights based on Nakagami-m distribution. This time they use RGB color model, HSV color model and Nakagami-m distribution for the brake light detection. First, the original video frame is transformed from RGB color model to HSV color model due to the characteristic of the contrast of V-channel between taillights and the background environment are large. Next Eq. (2.1) and Eq. (2.2) will be applied in preprocessing the sample image in Figure 2.1(a) Original input image of RGB color model, (b) the value channel of HSV color model in grayscale and (c) the result after segmentation process. The result for this project will be show in the Table 2.3 [4]. Table 2.3 shows the detection rate evaluated using dataset of four categories. The improvement from this project is shown in Table 2.4. Table 5 summarize the effectiveness in detection rate for both project.

Table 2.2: The detection rate evaluated using two cases [3]

	Ground Truth	Number of Detected	Detection Rate
Case 1	13	10	76.90%
Case 2	17	12	70.50%

$$T(u) = \begin{cases} 1, & if\ u \geq 0.4 \\ 0, & otherwise \end{cases}, \qquad (2.1)$$

$$U_T = U_v\ x\ T(U_v), \qquad (2.2)$$

Figure 2.1: (a) Original input image; (b) the value channel of HSV color (c) the result U_T after preprocessing using Eq. (2.2) [4]

Table 2.3: The detection rate evaluated using the dataset of four categories [4]

Video Classification			Ground Truth	Number of Detected	Detection Rate	Average
Case	Distance	No. of Vehicles				
1	closer	29	29	27	93.10%	86.30%
2		25	25	23	92%	
3	further	26	26	21	80.80%	
4		29	29	23	79.30%	

Table 2.4: Comparison between two projects [5]

Project	Average of Detection Rate
Frequency-Tuned Nighttime Brake Detection	73.7 %
Scattering-based Brake Light Modelling and Detection	86.30 %

Thammakaroon and Tangmchit used taillight characteristics such as area of red lights, size of the largest brake lights and prediction of a brake warning approach based on distance estimated from analysis of taillights in front. The algorithm uses a threshold obtained from statically collection of 50 sample images to detect red color on an RGB color model. RGB color model is used as the first step to ready the images so that it can be used in the next step. These researchers observed the light source by using camera. The camera is placed one meter away from the camera and the light source. Then, they use HSI color model is used to adjust the camera's gain based on the intensity value of the (I) channel. The brightness of the taillights were captured and the difference between active and inactive taillights gained from the camera will be recorded. Figure 2.2 shows the brightness of taillights for inactive and active taillights.

(a) (b)

Figure 2.2: The brightness of the taillights. (a) Inactive taillights. (b) Active taillights [5]

This methods will involve three stages which are detect the red color, calculate sizes and find location of the image and apply morphological method to indicate the detected brake lights. In the first stage, they use threshold method in RGB color model to detect red color in brake light. Then, in order to enhance the red regions they apply Gaussian smoothing to the original image. By using the upper and lower threshold, they are able to extract only red color pixels and take the binary value of the red color. Second stage, they use algorithm in order to find contours in the image frame, thus calculate the sizes and location of the image. Lastly, by using

morphological method, they indicate the detected brake lights by the bounding boxes as shown in Figure 2.3 (b). Figure 2.3 shows the example of detected brake lights.

(a) (b)

Figure 2.3: Example of detected brake lights. (a) The group of white pixels. (b) The detected brake lights are indicated by the bounding boxes [5]

Results from this system can attained a high accuracy about 90% detection in the driver's action prediction. The hypothesis, the collision risk, which derived from the taillights, has a close relationship with the actual brakes is supported. The experimental result accuracy will be tabulated in Table 2.5 [5]. Table 6 shows the accuracy of the rear-end collision risk estimation.

Table 2.5: The accuracy of the rear-end collision risk estimation [5]

Results	Percentage
Correct predictive	89.9997%
False positive	5.603%
False negative	4.400%

2.1.2 Sensor Based Concept

Kim *et al.* presented front and rear vehicle detection and tracking in the day and night using vision and sonar sensor. The use of sonar sensor is for detection and distance estimation within 10 m and use of image sensor is for over 10 m range. These researchers proposes a simple method that can be determine the light condition by observing several images and light condition is used by selecting one of several detection methods. Figure 2.4 will show how the system is implemented into the vehicle. These researchers uses two cameras so that it can detect vehicles in two different range, medium and far range. The cameras were installed by the side of a rear-view mirror and at the ceiling above the back seats. Meanwhile, the two sensors were installed at the front and rear bumpers.

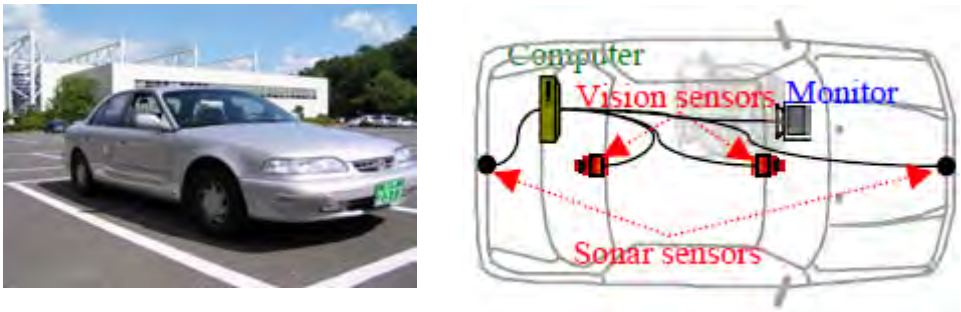

Figure 2.4: The hardware structure and the test bed [6]

In daytime, vehicle detection method is by image extract by the shadow region represented by the boundary between a vehicle and the road. They also use on-line template detection matching using mean image created by several consecutive detection results. However, no matter what templates or features they use, an appropriate algorithm must be applied to current environment. They saw it as an obstacle for them because it is hard to implement in real-time processing system. As the results, this project achieves an 85% of detection of vehicles in the performance rate of vehicle detection. Meanwhile, for the performance rate of vehicle tracking and restoration, this project achieves 96% tracking detection. The performance rate of the system will be show in Table 2.6 [6]. Table 7 shows that the performance rate of vehicle tracking and restoration rate.

Table 2.6: Performance Rate of Vehicle Tracking and Restoration [6]

Sample\ Detection result	Vehicle	Non-Vehicle
Vehicle	96%	4%
Non-Vehicle	2%	98%

2.2 Previous Research on Segmentation Method

In image processing, there are few steps involve in order to detect the color from an image and one of the method is image threshold. Thresholding is an important part in image segmentation, where we want to extract the object from the background. When we do the image processing which involve image segmentation, one of the common method of thresholding is Otsu's method [11]. In the next section, we will have a view of this method and perspective used in previous research.

2.2.1 Otsu's Method of Segmentation

Xiangyu et al proposed stroke-model-based character extraction from gray-level document images. In order to describe the local features of object as double-edges in predefined size, a stroke model must be implemented. By using gray-level thresholding techniques, they can choose which pixels are having gray levels lower than threshold value and which are not. For the pixels that lower than threshold value, it will labelled as black, else white. Eq.2.3 will shows the pixels output with some condition applied [7].

$$b(x,y) = \begin{cases} 1, & if\ f(x,y) < g(x,y)\ AND\ c(x,y) > c^{\emptyset} \\ 0, & otherwise \end{cases} \quad (2.3)$$