"I hereby declare that I have read through this report entitled "**Real-Time Video for Road Lane Marker (Urban Type) Using Image Processing**" and found that it complies the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering.

Signature :……………………………………………

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REAL-TIME VIDEO FOR ROAD LANE MARKER (URBAN TYPE) USING IMAGE PROCESSING

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Mechatronics Engineering

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2018

I declare that this report entitled "**Real-Time Video for Road Lane Marker (Urban Type) Using Image Processing**" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently in candidature of any other degree.

Signature :…………………………………………………………

Name : LIANG JIN CHUAN

Date :…………………………………………………………

To my beloved mother and father

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ABSTRACT

Road markers provide road information to driver to ensure road and their safety. Different type of markers indicate different kind of information. For example, double lane marker indicates that drivers are not allowed to overtake due to dangerous road condition. It can lead to road accident if the drivers do not follow the rule of the road marker or the road markers are not seen clearly by the drivers. Nowadays, road accidents become a concerning issue all over the world. In order to avoid the tragedy continues to happen, vision based system is developed to detect and classify those markers. Besides, the existing features are insufficient to allow a robust recognition. In this report, real-time video of three types of marker is developed using image processing and artificial neural network (ANN). The video is recorded in urban area at afternoon. The image processing and classification are done using MATLAB software. The image processing techniques include grayscale conversion, image sharpening, noise removal, cropping, resizing and feature extraction. The features selected are the length of the feature vector on HOG and LBP. These feature vectors are later to be trained using neural network pattern recognition tool, to classify the data getting from the feature. The validation for the sample is 15% while the testing for the sample is 15% and the rest is used for training. The result shows an accuracy of 99.4% with HOG and LBP features as input vectors.

ABSTRAK

Penanda jalan memberikan maklumat jalan kepada pemandu untuk memastikan keselamatan mereka dan keamanan jalan raya. Penanda yang berbeza menunjukkan maklumat yang berlainan. Sebagai contoh, penanda yang mempunyai dua barisan menunjukkan bahawa pemandu tidak dibenarkan memotong kerana berada di kawasan yang merbahaya. Hal ini dapat mengakibatkan kemalangan jalan raya jika pemandu tidak mengikuti peraturan penanda ataupun pemandu tidak dapat melihat penanda jalan dengan jelas. Kini, kemalangan jalan raya menjadi isu yang penting di seluruh dunia. Untuk mengelakkan tragedy terus berlaku, sistem berasaskan visi telah dibangunkan untuk mengesan dan mengklasifikasikan penanda-penanda tersebut di jalan raya. Selain itu, terdapat ciri-ciri yang tidak mencukupi untuk membolehkan pengiktirafan yang teguh. Dalam laporan ini, video dalam masa nyata dengan tiga jenis penanda jalan telah dilakukan penyelidikan menggunakan pemprosesan imej dan jaringan saraf tiruan (ANN). Video telah dirakamkan di kawasan bandar pada masa tengah hari. Pemprosesan imej dan klasifikasi pula dilakukan dengan menggunakan perisian MATLAB. Teknik pemprosesan imej termasuk penukaran warna kepada kelabu, pengasahan imej, penyingkiran hingar, pemotongan imej, saiz semula imej dan pengekstrakan ciri. Ciri-ciri yang dipilih adalah kepanjangan vektor ciri pada HOG dan LBP. Vektor ciri ini kemudiannya akan dilatih menggunakan alat rangkaian saraf dalam MATLAB iaitu alat pengenalan corak rangkai neural, untuk mengklasifikasikan data yang diperoleh dari ciri tersebut. Pengesahan sampel adalah 15% manakala ujian bagi sampel adalah 15% dan selebihnya digunakan untuk proses perlatihan. Hasil daripada proses perlatihan menunjukkan ketepatan 99.4% dengan HOG dan LBP.

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LIST OF ABBREVIATION

FYP – Final Year Project

UTeM – Universiti Teknikal Malaysia Melaka

ANN – Artificial Neural Network

ROI – Region of Interest

FYP- Final Year Project

ADAS – Advanced Driver-Assistance Systems

MIROS – Malaysian Institute of Road Safety Research

GPS – Global Positioning System

IPM – Inverse Perspective Mapping

RPROP – Resilient Back Propagation

HOG – Histogram of Oriented Gradients

POI – Point of Interest

MLP – Multi-Layer Perceptron

USB – Universal Serial Bus

SSD – Solid State Drive

HDD – Hard Disk Drive

LBP – Local Binary Pattern

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CHAPTER 1

INTRODUCTION

In Malaysia, road accident happens every year and has become a concerning issue. The statistic on the road accidents in Malaysia increases from 2014 to 2016. Based on the road accident data in Malaysia, there is a relation between the population and the death rate. The amount of road deaths increases from year to year due to the growth population in Malaysia [1].

Road marker is a kind of hint or indicator that is used on a road surface in order to give information. They are widely placed with the road marking machines. Besides, they are applied in other facilities used by vehicles to mark parking spaces or designate areas for other purposes. It is also used to show regulation for parking and stopping.

They are used to control and guide the traffic. Besides, they play an important role on urban roads because they ensure the road safety and make the flow of travel paths smooth. They are also used on roadways to provide guidance to the road users such as drivers and pedestrians. Different types of marker indicates different kind of information to minimize the confusion and uncertainty about their meaning. For example, most common types of road markers are single dash line and double solid lines. Single dash line road marker indicates that overtaking of vehicles is allowed whereas double solid line road marker indicates that overtaking of vehicles is not allowed.

Today, road markers are used to send and give information to the driver spanning navigational, safety and enforcement issues leading to their use in road environment understanding within advanced driver-assistance systems and implementation for future use in autonomous road vehicles.

Year	Registered Vehicles	Population	Road Crashes	Road Deaths	Serious Injury	Slight Injury	Index per 10,000 Vehicles	Index per 100,000 Population	Indeks per billion VKT
1997	8,550,469.00	21,665,600.00	215,632.00	6,302.00	14,105.00	36,167.00	7.37	29.10	33.57
1998	9,141,357.00	22,179,500.00	211,037.00	5,740.00	12,068.00	37,896.00	6.28	25.80	28.75
1999	9,929,951.00	22,711,900.00	223,166.00	5,794.00	10,366.00	36,777.00	5.83	25.50	26.79
2000	10,598,804.00	23,263,600.00	250,429.00	6,035.00	9,790.00	34,375.00	5.69	26.00	26.25
2001	11,302,545.00	23,795,300.00	265,175.00	5,849.00	8,680.00	35,944.00	5.17	25.10	23.93
2002	12,068,144.00	24,526,500.00	279,711.00	5,891.00	8,425.00	35,236.00	4.90	25.30	22.71
2003	12,819,248.00	25,048,300.00	298,653.00	6,286.00	9,040.00	37,415.00	4.90	25.10	22.77
2004	13,828,889.00	25,580,000.00	326,815.00	6,228.00	9,218.00	38,645.00	4.52	24.30	21.10
2005	15,026,660.00	26,130,000.00	328,264.00	6,200.00	9,395.00	31,417.00	4.18	23.70	19.58
2006	15,790,732.00	26,640,000.00	341,252.00	6,287.00	9,253.00	19,885.00	3.98	23.60	18.69
2007	16,813,943.00	27,170,000.00	363,319.00	6,282.00	9,273.00	18,444.00	3.74	23.10	17.60
2008	17,971,907.00	27,730,000.00	373,071.00	6,527.00	8,868.00	16,879.00	3.63	23.50	17.65
2009	19,016,782.00	28,310,000.00	397,330.00	6,745.00	8,849.00	15,823.00	3.55	23.80	17.27
2010	20,188,565.00	28,910,000.00	414,421.00	6,872.00	7,781.00	13,616.00	3.40	23.80	16.21
2011	21,401,269.00	29,000,000.00	449,040.00	6,877.00	6,328.00	12,365.00	3.21	23.70	14.68
2012	22,702,221.00	29,300,000.00	462,423.00	6,917.00	5,868.00	11,654.00	3.05	23.60	13.35
2013	23,819,256.00	29,947,600.00	477,204.00	6,915.00	4,597.00	8,388.00	2.90	23.10	12.19
2014	25,101,192.00	30,300,000.00	476,196.00	6,674.00	4,432.00	8,598.00	2.66	22.00	10.64
2015	26,301,952	31,190,000	489,606	6,706	4,120	7,432	2.55	21.5	9.6
2016	27,613,120	31,660,000[e]	521466[a]	7152[a]	NA	NA	2.59	22.6	NA

e = estimated value from Department of Statistics Malaysia
a = media statement
NA = Not available (The official figures are not available yet)

Figure 1.1: General Road Accident Data in Malaysia (1997-2016)[1]

There are several causes leading to the road accidents. For example, human error, condition of the road and vehicle problem [27][28]. According to Transport Minister Datuk Seri Liow Tiong Lai, a total of 7152 people died in road accidents in Malaysia in the year 2016 and he believed that 80.6% of the road accidents are caused by human error [2]. This was proven when a research by the MIROS shows that the main reason of road accidents was caused due to people driving recklessly and ignoring the traffic rules. Even though there is law enforcement and camera installation on the road to punish and fine those who break the rules, this incident still often happen. In order to reduce this tragedy continues happening, researchers have been conducting research towards the autonomous industry.

1.1 Motivation

Road accidents caused almost 40,000 people died during 2008 in European Union [31]. Dropping of death rate for over 30% from 2001, the European Transport Commission is working to revise and update the goals proposed in 2001 [32]. The aim is to reduce the number of accidents.

From the automotive industry, several development have been done in the last years. The cruise control (CC) that allows the driver to set a speed driving or its extension to the adaptive cruise control (ACC) where the vehicle is able to follow a leading car in highways are two of the most popular advanced driving assistance system (ADAS) developed by the car manufacturers to make the driving task easier and convenient.

The era for the future is for there to be an improvement from simple driving aids to automatic driving controls. Among all the different solutions to these problems that have been proposed, the advances of autonomous vehicles is currently an open field of research. Research on developing automated vehicles to improve the road safety and efficiency of road is indeed one of the most popular studied topics in the field of intelligent transportation systems (ITS) [30].

In this case, vision based system for road markers classification could be developed and implemented on the vehicle to assist the driver when they are driving. Road marker recognition and classification is a crucial research for people in the application and implementation of autonomous vehicle system. It is a system attached to a vehicle installing a camera to recognize the types of road marker. The road markers which mark the lane will help the drivers to avoid any accidents and keep track on the road within the detected markers.

Speaking of autonomous vehicle, the concept was first exposed at GM's Futurama exhibit at the World's Fair in 1939. Autonomous vehicle can be defined as self-driving car, robotic car or large sized unmanned ground vehicle that has the ability to navigate itself according to its environmental issues without the assistance of human. Autonomous vehicles use many kinds of techniques to sense their environment. Some of the examples are radar, GPS, computer vision and etc. In 1977, there was first autonomous vehicles in Japan which used camera and analogue computing to process the signals. However, in the year of 1987, the research project had been directed from signal based technologies toward vision-based technologies. In 2004, first Grand

Challenge was held and there were 15 autonomous cars competing in 150-mile challenge to promote the development of autonomous cars [29][33][34]. After six years of time, Google had launched a Google Driverless Car program to rack up more than 140,000 miles with a fleet of autonomous Toyota Prius hybrids. One year later, the state of Nevada approved the first law of allowing driverless cars whereas other nations begun to introduce the legislation law.

Apart from that, according to the statistical report from Boston consulting group which is shown in Figure 1.2, there would be a huge demand of autonomous cars in the year 2035.

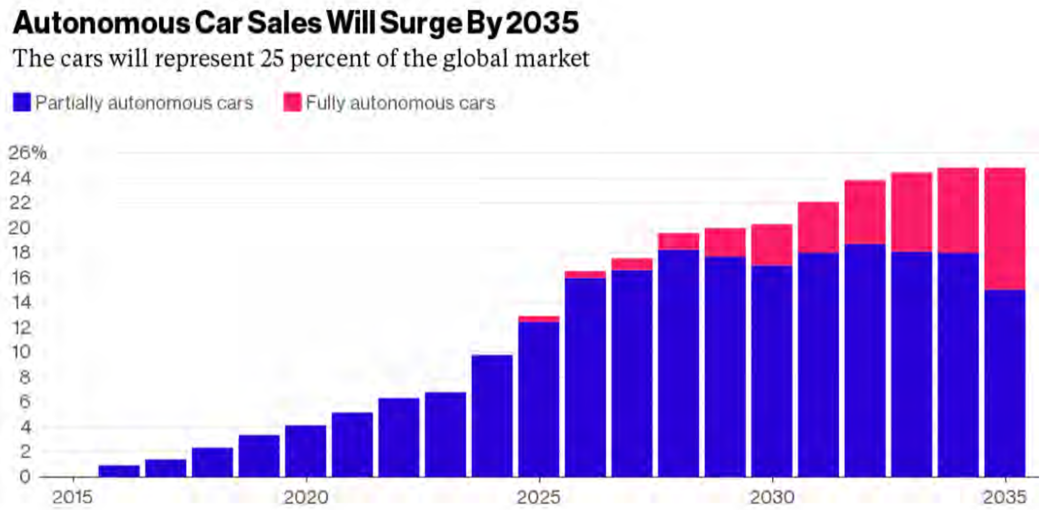

Figure 1.2: Statistical report of autonomous cars sales

In order to achieve the target of fully autonomous industry, the system applied to the autonomous cars are required to be improved. This is the reason and the motivation that is decided to develop a real-time video system of road lane marker.

1.2 Problem Statement

Many people are killed in car accidents each year. According to the statistical report on car accidents in Malaysia, the cases of road deaths increased from year 2014 to 2016. Most of these accidents are caused by the drivers carelessness, road condition and vehicle defection. Besides, the bad condition of the road markers also confused the drivers' mind as they did not know the type of the road markers [1]. Therefore, a vision based system is required to overcome the problem in order to reduce the rate of road accidents in Malaysia. The existing recognition system is not accurate as the existing features are insufficient to allow a robust recognition [16][20][21][22][23].

1.3 Objectives

The objective of this project is to:

i. To classify single dash line, double solid line and double dash line road markers on the urban road using neural network method.

ii. To develop a real-time recognition using image processing method.

iii. To analyse and improve the classification accuracy getting from the video using MATLAB software.

1.4 Scope

This research is focused on three types of road markers which are double solid line, double dash line and single dash line. An USB camera, Logitech C310, was used to capture the real time video. The video was recorded at Jalan Bukit Beruang in Ayer Keroh, Melaka, at the time of afternoon from 2.00 pm to 2.30 pm which had good illumination. The vehicle speed will be fixed around 40 km/h to 60 km/h to prevent crashing on the video captured due to the vibration while recording. Any shadows that causing the glaring effect will not be used in the training process.

a: Double solid line

b: Double dash line

c: Single dash line

Figure 1.3: Types of road marker (a), (b) and (c)

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and Basic Principles

In this research, most theory and principles will be covered on machine vision and image processing. Machine vision is a system that recovers useful information from two-dimensional projections. The recovery requires inversion of a many-to one mapping. Therefore, knowledge about the scene and geometry of projection are needed for recovering the information. Machine vision has been now used widely for various applications such as advanced driver-assistance systems (ADAS) and industry purposes [3]. For example, Figure 2.1 shows the application of ADAS.

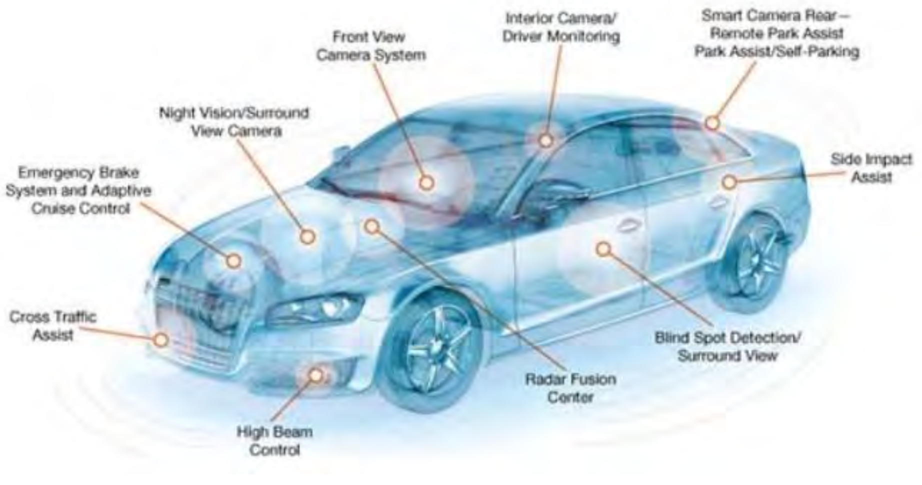

Figure 2.1: ADAS application

As we can see, due to various application of machine vision in different fields, different techniques for recovering information from images have been discovered.

One of the field which is related closely to machine vision is image processing. Image processing processes the original image into another image to retrieve the desired information easier [3]. An image can be defined as a 2D function, f(x,y), where x and y are spatial coordinates, and the amplitude of f at any pair of coordinates (x,y) is called the intensity or gray level of the image at that point. A digital image is formed when the amplitude values of f, x and y are all finite. These finite number of elements which has particular elements and value are referred as image elements or pixels. Pixel is the term to denote the digital image elements. These pixels form an original image and consists of varied intensity [4]. For example, in colour image processing, a colour is usually represented by 3 components which are red, green and blue.

Generally, there are many types of image processing techniques included in this field. For examples, image enhancement, image segmentation, feature extraction and image classification [5].

2.1.1 Image Enhancement

In digital image pre-processing, image data that collected from the sensors restrain errors related to geometry and pixels intensity value. Appropriate mathematical models are used to correct these errors. Image enhancement is the method that modify the image by adjusting the pixel intensity values to enhance its visual effect. Image enhancement involves many techniques to improve the image or convert it to be suitable for human or machine interpretation. Sometimes images obtained from camera can be lacked in contrast and brightness due to illumination condition when capturing images. These images are considered having different kind of noise. Therefore, image enhancement aims to accentuate certain image features for subsequent analysis or for image display [12]. For example, some of the enhancement techniques are contrast stretching, noise filtering and histogram modification.

2.1.1.1 Constrast Stretching

Some images are homogeneous. They do not have any difference in their levels. In terms of histogram representation, they are characterized as the occurrence of very narrow peaks. The homogeneity can be due to the illumination condition [11]. Thus, the images are difficult for interpretation because only a narrow range of gray-levels in image having provision for wider range of gray-levels. In this case, contrast stretching can be used to stretch the narrow range to a new dynamic range.

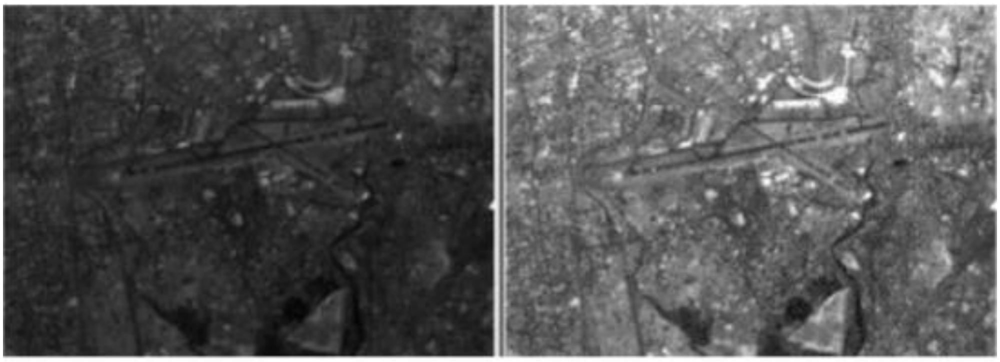

Figure 2.2: Contrast Stretching [11]

Assume an image I with an intensity value range [0,1], the energy functional is established:

$$E(I) = 1/2\ (I(x, y) - 1/2\ )\ 2dxdy - 1/4\ |I(x, y) - I(u, v)|dxdydudv \qquad (1)$$

The above equation is solved using the steepest descent with an auxiliary variable t as follows:

$$\frac{\partial I(x,y,t)}{\partial t} = [1 - \frac{I(x,y,t)}{Imax}]A\Omega \ - \ A(I(x,y,t)) \qquad (2)$$

where AΩ is the image area and A(·) is the function of the area. Suppose that the above equation and all other evolutionary equations have initial conditions:

$$I(x, y, 0) = I0(x, y) \qquad (3)$$

and Neumann boundary conditions:

$$\frac{\partial I}{\partial n} = 0 \qquad (4)$$

where n is the orientation perpendicular to the boundary. Equation (2) has a unique steady-state solution:

$$I(x, y, \infty) = Imax \times H(I) \qquad (5)$$

where H(I) is the cumulative distribution histogram of image I. This solution is the result of traditional HE method for the image. More generally, the equation (2) can be rewritten as follows [24]:

$$\partial I \frac{(x,y,t)}{\partial t} = f(I(x,y,t)) - I(x,y,t) \quad (6)$$

where f(I(x, y, t)) is an arbitrary image enhancement transformation.

2.1.1.2 Noise Filtering

Noise filtering is used to filter the unnecessary or undesired information from an image. It also removes noises from the images. There are many types of filters such as low pass, high pass, mean, median and so on [11].

Figure 2.3: Noise Filtering [11]

There is statistical methods for image filtering, though they are infrequently used as they are computationally demanding. For Gaussian noise, it can model the pixels in a greyscale image as auto-normally distributed, where each pixel's "true" greyscale value is normally distributed with mean equal to the average greyscale value of its neighbouring pixels and a given variance.

Let δ_i denote the pixels adjacent to the *i*th pixel. Then the conditional distribution of the greyscale intensity (on a [0,1] scale) at the *i*th node is:

$$P(x(i) = c|x(j)\forall j \in \delta i) \propto e^{-\frac{\beta}{2\lambda}\sum_{j\epsilon\delta i}(c-x(j))^2} \quad (7)$$

for a chosen parameter ß ≥ 0 and variance λ. One method of noise filtering that uses the auto-normal model uses the image data as a Bayesian prior and the auto-normal density as a likelihood function, with the resulting posterior distribution offering a mean or mode as a noise removed image [25].