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FINAL YEAR PROJECT 2

(FULL REPORT)

REAL TIME VIDEO TRAFFIC LIGHT DETECTION AND INTERPRETATION USING IMAGE PROCESSING METHOD

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"I hereby declared that I have read though this report entitle "Real Time Video Traffic Light Detection and Interpretation Using Image Processing Method" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronic Engineering"

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REAL TIME VIDEO TRAFFIC LIGHT DETECTION AND INTERPRETATION USING IMAGE PROCESSING METHOD

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

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I hereby declared that this report entitle “Real Time Video Traffic Light Detection and Interpretation Using Image Processing Method” is the result of my own work except as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

Name : Nur Amalyna binti Ramlan

Date : ……

To my beloved mother and father

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ABSTRACT

The purpose of this project is meant to develop a real-time traffic light recognition using image processing algorithm. Invariant in factor lightning and weather condition that lead to misinterpret the colour of traffic light is one of the factor of accident at traffic light conjunction besides the behaviour of the driver itself. The process to identify the colour and shape of traffic light are Image Acquisition, Pre-Processing, Detection, Feature Extraction and Interpretation. Simple thresholding method that act as colour segmentation provides a better division of the traffic light colours. Circle Hough Transform and HSV colour features based on the traffic light aspect are used to decide whether the spots on the frames are likely to be traffic lights' colour and shape. The detection of traffic light is obtained after identifying the feature that need to be extracted at the end of the result and by comparing the pixel value in recognition process. The research has been improved by focussing on detection and interpretation of traffic light based on real time video rather than image sample as the input by processing all frames contained in the video.

ABSTRAK

Tujuan projek ini adalah untuk menghasilkan pengiktirafan lampu isyarat dalam masa nyata menggunakan algoritma pemprosesan imej. Kepelbagaian dalam faktor pemcahayaan dan keadaan cuaca yang membawa kepada kesalahan dalam mentafsir warna lampu isyarat adalah salah satu faktor kemalangan selain daripada tingkah laku pemandu itu sendiri. Proses untuk mengenal pasti warna dan bentuk lampu isyarat adalah melalui proses Perolehan Imej, Pemprosesan pra, Pengesanan, Pengekstrakan dan Tafsiran Ciri. Kaedah thresholding yang ringkas bertindak sebagai segmentasi warna untuk membezakan warna setiap lampu isyarat dengan lebih baik. Circle Hough Transform (CHT) dan ciri-ciri warna HSV berdasarkan aspek lampu isyarat digunakan untuk menentukan sama ada bintik di bingkai mungkin berwarna dan mempunyai bentuk yang sama seperti lampu isyarat. Pengesanan lampu isyarat akan diperolehi selepas mengenal pasti ciri yang perlu diekstrak pada akhir proses pengekstrakan. Penyelidikan ini telah dipertingkatkan dengan menumpukan pada pengesanan dan penafsiran lampu isyarat berdasarkan video yang dirakam ketika masa nyata berbanding sampel imej sebagai input.

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CHAPTER 1

INTRODUCTION

This chapter will represent the background and motivation to the study, the statement of the problem, general and specific objective and the scope of the study.

1.1 Introduction

Traffic light was designed normally at the busiest street and highway intersection to achieve a purpose of facilitating the safe movement of cars and avoiding car collisions. Notwithstanding, The Federal Highway Administrations guarantees that around 45% of auto accidents occur at a street crossing point and the reason is normally identified with running a stop sign [1].

A pressing need for the introduction of advanced technology and equipment to prevent increasing number of accident must be done. The world are approaching a point where car can drive themselves better than humans. This lead to the creation of autonomous car which has been rolled out earlier by Tesla, Mercedes and Google. The detection of traffic light colour is the focal point in autonomous car [2]. This type of detection system is more reliable and faster which will be a great solution of producing zero accidents as it will control the car automatically and efficiently to obey the traffic light sign. Apart of protecting drivers from death and injury, it also eliminates property damage, reduces traffic problems and could bring down car insurance rates. [3]

1.2 Motivation

The detection of traffic lights has a critical place everywhere throughout the world. When looking at the reasons of expanding car accidents, it appears that a large portion of them are caused by human mistake. [4] Violating a red traffic light is one of the factor of serious road car accident in Malaysia. Detection of traffic lights may ensure securing the human life. Some of these reasons of violating the traffic light are because of driver negligence, driver disregard and lack of traffic lights at some point. Autonomous vehicles have been produced on account of new technology to reduce the accident caused by traffic lights. [5] Real time traffic light recognition using image processing method technique will help to detect the variant colour of traffic light. The system in these vehicles can automatically detect traffic lights and this system can alert the driver.

Over the past few decades, lots of attempts have been made to autonomous vehicles. High demand in autonomous vehicle also lead to the research about this project. Moreover, real time video traffic light detection system is still under research in Malaysia which is one of the purpose to make a deeper research about this project. Nowadays, driving on highway with autonomous vehicles has turned out to be increasingly dependable, while fully autonomous driving in real urban environment is still an extreme and challenging task .Robust detection and recognition of traffic lights is fundamental for autonomous vehicle to take appropriate actions on intersection in urban environment. However robust detection of traffic lights is not easy to be carried, for there would be a horrendous chaos of objects in an image in which colours are similar to the one of the traffic lights, and the shape of traffic light is so simple that it's hard to extract sufficient features [6]. The worse situation may be met that the traffic lights have a variety of types, of which, some are horizontal arrangements while some are verticals, and also, some are composed of only circles while some include arrows.

1.3 Problem Statement

There are many strict rules and penalties made by the government, most of drivers still do not adhere to the rules and disregard their own safety. They purposely break and ignoring the traffic light sign especially when the colour turns into red. There are three types of traffic light's colour that is green, yellow and red which has their own function. Most of the driver especially senior citizens always missed the traffic light sign [7]. As a precaution, they need to be alerted earlier at a certain distance which will prevent an emergency brake and car collisions. Other than that, people with colour vision deficiency need a technology which able to interpret the colour of traffic light sign for them while driving. They did not get any chance to take their driving license because of their disability especially to detect the colour of the traffic light and cars' brake lamp. Invariant in factor lightning and weather condition which may lead to misinterpret the colour of traffic light is also one of the main factor of car accident in Malaysia.

1.4 Objective

The fundamental target of this examination is to build up a proficient traffic light recognition framework. The objective of this project is as follows:

- To develop a real-time traffic light recognition using image processing algorithm.
- To extract identified and related features from video to do classification process
- To improve the accuracy of the classification process.

1.5 Scope Of Research

The study of this research is focussing on the detection of three different traffic light colour based on real time video. The real time video is recognized during day time with a good illumination only. The type of traffic light for testing is circle shape only which means that arrow and human walking traffic light are not considered in this research. There are only traffic lights in the area of Ayer Keroh and Durian Tunggal that being covered in this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and Basic Principle

Image Processing is a method to improve raw images earned from cameras or sensors placed on transportation and satellites or pictures taken for various applications. Image processing includes something that related to image representation, compression method and various complex operation, which can be executed on the image data. Image enhancement operations like sharpening, blurring, brightening and edge enhancement is under the group of image processing. The input is an image from cameras or videos while an image with a set of characteristics will be the output. An image will be used in this technique is in two-dimensional signal and standard signal-processing method will be implemented to it. Image processing frequently corresponding to digital image processing.

2.1.1 Image Acquisition:

Image acquisition or can be called as digital imaging is the formation of photographic images. The term is often assumed to imply or include the processing, compression, storage, printing, and display of such images. Image is basically in the form of two-dimensional function f(x, y) on the plane that can be seen in the Figure 2.1 below. The intensity or grey level of the image can be determined by the amplitude of image at any point. These x and y values will be converted to a fixed discrete values to produce a digital image. The input image is taken from stare data base and drive data base. Analog image must be converted to digital image so that digital computer can process the image [8]. Each digital image comprise of a fixed elements and each fixed element represent a pixel.

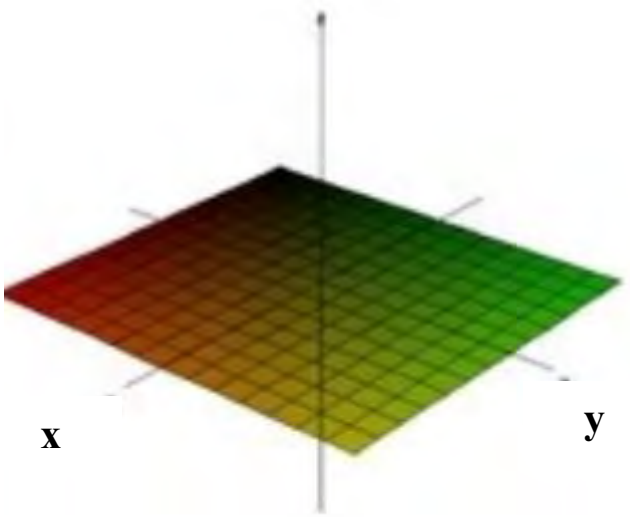

Figure 2.1: Two-dimensional (2D) function f(x, y)

2.1.2 Type of Colour Based-Technique

2.1.2.1 RGB Colour Space Technique

Humans perceive colour through wavelength-sensitive sensory cells called cones. There are three unique assortments of cones, each has an alternate affectability to electromagnetic radiation (light) of various wavelength. One cone is basically delicate to green light, one to red light, and one to blue light. By emitting a confined combination of these three hues (red, green and blue), and thus stimulate the three sorts of cones freely, any detectable colour can be generated. This cause colour images that contain the amount of Red (R), Green (G) and Blue (B) often to be stored as three separate image matrices in RGB format. The significant purpose for the RGB colour model is for the detecting, portrayal and show of image in electronic system, for example, TVs, PCs, colour and most video camera. However it has likewise been utilized as a part of traditional photograph.

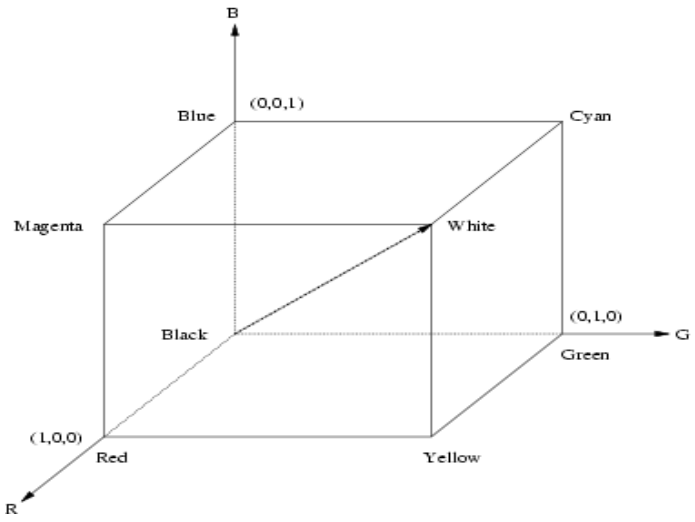

Figure 2.2: The geometry of the RGB shading model for determining hues utilizing a Cartesian facilitate framework

The three additive primary colours, red, green, and blue is a starting to come out the name of the model. From the RGB display, an image comprises of three image planes as shown in Figure 2. 2, one in each of the primary hues: red, green and blue. A specific colour is determined by indicating the amount of each of the primary segments present [9].

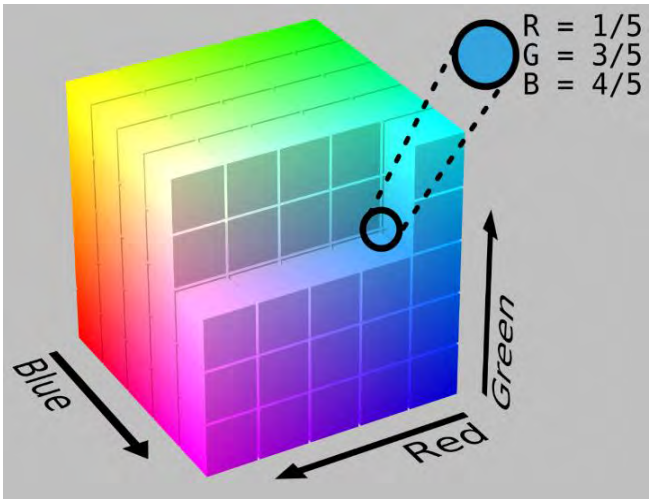

Figure 2.3: The RGB colour cube

The RGB colour model is a colour addition. Broad array of colours is reproduced by mixing together the red, green and blue light in various ways. The colours present in the light is added to produce new colours, and it is suitable for the blending of coloured light. As referring to the Figure 2.3 above, it demonstrates the additive mixing of red, green and blue primaries. Three secondary colours yellow (red + green), cyan (blue + green) and magenta (red + blue), and white ((red + green + blue) are formed from the mixing of all those of colours.

2.1.2.2 HSV Colour Space Technique

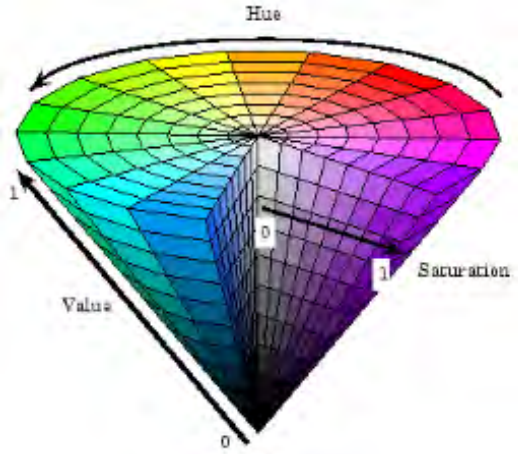

Figure 2.4: Cone of HSV colour space

HSV terms is indicating to three values that is Hue, Saturation and Value/Brightness. Its colour model for HSB and HSV is the same. This colour space characterize about colours in terms of *Hue* which is the actual colour, *Saturation* indicates the amount of grey r while *Brightness* refers to the quantity of white or black that is being mixed in the colour [9]. A cone or cylinder illustrate the HSV colour wheel. The depth explanations of the HSV is explained at bullet list shown below while referring to the Figure 2.4:

- Hue is expressed as a number that rotate counter clockwise at angle from 0 to 360 degrees. It will show the certain value of hue such as the hue of red that starts at 0, yellow at 60, green at 120, and blue at 240. If the hue value is 0 or 255, the colour will be black and white which will not be affected by saturation and brightness.
- Saturation is the amount of grey from zero percent to 100 percent in the colour. The value will increase as the colour move away from the axis to the lateral surface from 0 (0 %) to 255 (100 %). The colour will change from colourfulness to fully saturate as the value raised.
- Value define about the brightness or concentration of the white colour. It works in conjunction with saturation. The value is in between 0 (0%) and 255 (100%).

At the vertex of the cone represent the black colour and as the height move upwards to the base, the value will increase to produce lighter colour.

The first step HSV colour is by selecting one of the available hues. After that, shade and brightness value will be adjusted. It is proven that this kind of colour space can present colour that similar to the way of how human identify colour which is the drawback of RGB colour space.

HSV isolated luma (image intensity) from chroma (colour information). This colour space is frequently used in doing histogram equalization that need only the intensity of component rather than colour component alone. The factor of regularly using of HSV colour space in many application is simply due to the wide available of code for converting between RGB and HSV besides is easily implemented. The formula to find HSV value from RGB value [9] is as follows:

To find the *Hue* Value:

$$H = \begin{cases} \dfrac{60\,(G-B)}{S} & , \quad if\ V = R \\ 180 + \dfrac{60-(B-R)}{S} & , \quad if\ V = G \\ 240 + \dfrac{60\,(R-G)}{S} & , \quad if\ V = B \end{cases} \tag{2.1}$$

To find the *Saturation* value:

$$S = \frac{255\,(V - \min(R,G,B))}{V} \tag{2.2}$$

To find the *Brightness* value:

$$V = \max(R,G,B) \tag{2.3}$$

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2.1.3 Image Enhancement

Image enhancement is the process of modifying digital images so that the results are more appropriate for display or further analysis. Key characteristics is easier to be identified when noise has been eliminated.

2.1.3.1 Morphological Operation

Morphological image processing is a set of non-linear process related to the shape or analysis of features in an image. Morphological operations really suited to the processing of binary images because it depends on the respective ordering of pixel values rather than their numerical values. Greyscale images also should applied this morphological operations because their light transmission functions are unidentified.

Dilation and erosion are fundamental of morphological processing operations. The interaction of a set called a structuring element with a set of pixels of interest in the image will produce both dilation and erosion process. The structuring element has both a shape and an origin.

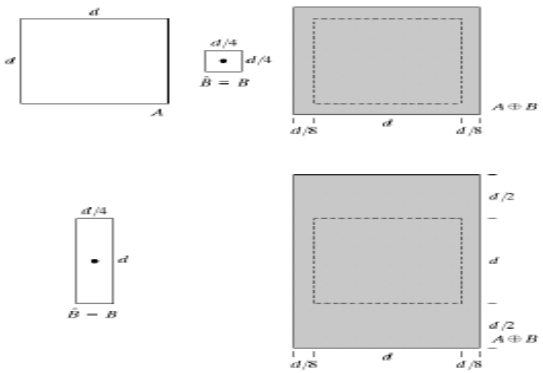

Figure 2.6: Dilation process

Dilation is any pixel in the output image touched by the  in the structuring element [11] as shown in the Figure 2.6 above set to ON when any point of the structuring element touches a ON pixel in the original image. This tends to close up holes in an image by expanding the ON regions. It also makes objects larger. The value of the output pixel is the *maximum* value of all the pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to the value1, the output pixel is set to 1.

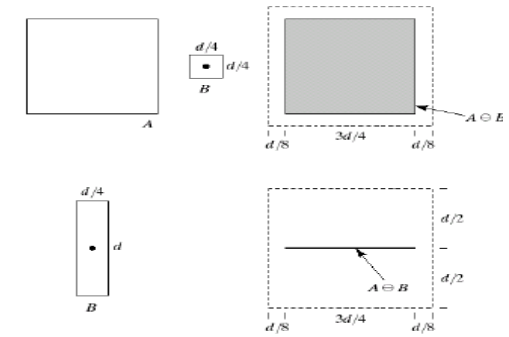

Figure 2.7: Erosion Process

Erosion is any pixel in the output image touched by the  in the structuring element is set as shown in the Figure 2.7 above to ON when every point of the structuring element touches a ON pixel in the original image [11]. This tends to makes objects smaller by removing pixels. The value of the output pixel is the *minimum* value of all the pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0.

The Figure 2.8 below shows the example of eliminating spot noise process from images using erosion and dilation process.

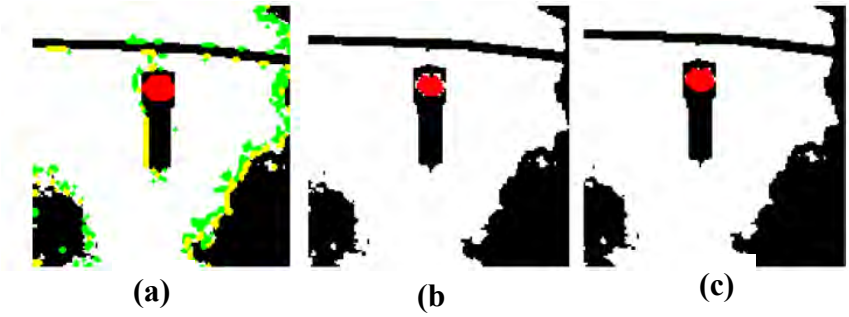

Figure 2.8: Eliminating spot noise from images. (a) Original image, (b) eroded, image and, (c) dilated image.

2.1.3.2 Circle Hough Transform

Circle Hough Transform (CHT) is used to detect circular shape of traffic light in a digital image and it is carried out after Edge Detection In this method, the curves of a given shape can be set apart [12].

There are two stages in this method which are fixing radius. This can discover optimal centre of circles in a two dimensional, 2D parameter space. Besides, optimal radius in one dimensional, 1D parameter space need to be found in the second stage. The parameter space would be three dimensional, (a, b, r). The parameter space would be decreased to 2D. The centre point of the original circle related to the intersection point of all circles as shown in Figure 2.9 in the parameter space and the intersection point can be located by using accumulator matrix. The voting number of points increased by one the circle passing through it. The centre of the circle can be determined by having the local maxima point of position (a, b) in the parameter space. Figure 2.9 below shows the intersection of circle to find the centre of the circle.

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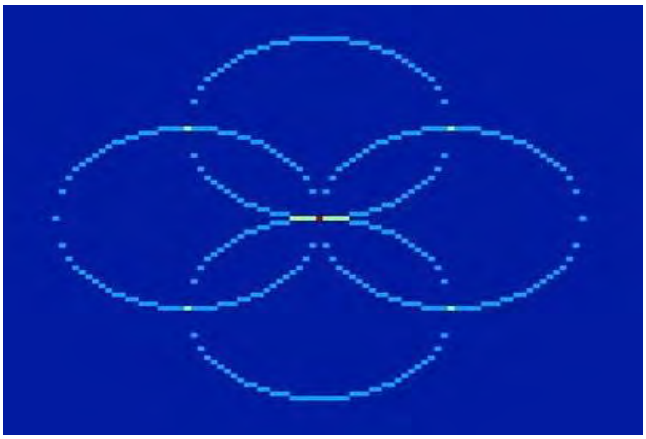

Figure 2.9: Intersection of circle