Traffic Light Detection and Counter Recognition using video images and Artificial Intelligence

HEFDHALLAH ABDULATEF SENAN AL-KUMAIM

BACHELOR OF MECHATRONICS ENGINEERING WITH HONOURS

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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HEFDHALLAH ABDULATEF SENAN AL-KUMAIM

A report submitted
in partial fulfillment of the requirements for the degree of
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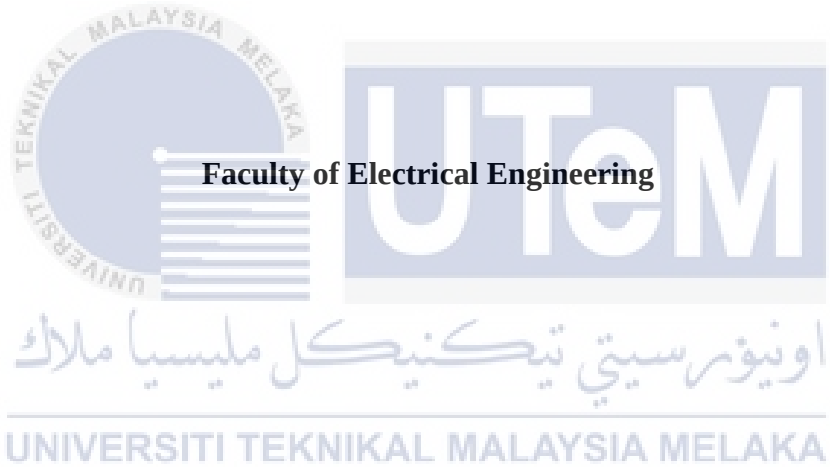

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled “Traffic Light Detection and Counter Recognition using video images and Artificial Intelligence is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : Hefdallah

Name : HEFHALLAH ABDULATEF SENAN AL-KUMAIM

Date : 05/7/2021

APPROVAL

I hereby declare that I have checked this report entitled “Traffic Light Detection and Counter Recognition using video images and Artificial Intelligence” and in my opinion, this thesis complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : IR. DR. ZAMANI BIN MD. SANI
PENSYARAH KANAN
Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

Date : 5/7/2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Traffic light control systems are widely used for the purpose of monitoring and controlling the automobiles flow through the junction of many roads. Smooth motion of cars in the public transportation routes is the aim of invention and installation of the traffic light. However, ADAS (Advanced Driver Assistance System) is a technology used in vehicles which helps drivers for driving. ADAS is required to be implemented in vehicles for the purpose of providing guidance for drivers and enhancing a better safety for vehicles and roads by minimizing human error which often occur at roads intersections. Besides, recognition of the countdown timer of traffic light provides an input to the system of autonomous vehicles technology of the remining time on the traffic light in order to have a more accurate system in term of controlling the vehicle's speed. Therefore, this project aims to design a vision system for detecting and recognizing traffic light with the counter digits. The proposed method suppressed the background by annotating all the candidates from the dataset which contains 2600 as well as classifying them to their respective classes which was accomplished by using Cash Value Accumulation Test (CVAT). The annotation files were merged with the original images and preprocessed using Roboflow. after uploading the dataset Roboflow generates a link to be used in Google Colab to import the dataset for training purpose to be validated and tested further. The algorithm used for object detection and recognition is YOLOv5 algorithm The evaluation of the method used was tested by 100 frames per class. The experiment resulted in an excellent detection and recognition rates of which the system was trained to with overall confidence rate of object detection varies between 80% to 90% as well as the accuracy of testing dataset which achieved an average of 95% to 100%.

ABSTRAK

Sistem kawalan lampu isyarat digunakan secara meluas untuk tujuan memantau dan mengawal aliran kenderaan melalui persimpangan banyak jalan. Pergerakan kenderaan yang lancar di laluan pengangkutan awam adalah tujuan penemuan dan pemasangan lampu isyarat. Walau bagaimanapun, ADAS (Advanced Driver Assistance System) adalah teknologi yang digunakan dalam kenderaan yang membantu pemandu untuk memandu. ADAS diharuskan dilaksanakan dalam kenderaan dengan tujuan memberikan panduan bagi pemandu dan meningkatkan keselamatan yang lebih baik untuk kenderaan dan jalan raya dengan meminimumkan kesalahan manusia yang sering terjadi di persimpangan jalan. Selain itu, pengiktirafan pemasa undur lampu isyarat memberi input kepada sistem teknologi kenderaan autonomi masa mengingatkan semula pada lampu isyarat untuk memiliki sistem yang lebih tepat dalam hal mengawal kelajuan kenderaan. Oleh itu, projek ini bertujuan untuk merancang sistem penglihatan untuk mengesan dan mengenali lampu isyarat dengan digit pembilang. Kaedah yang dicadangkan menekan latar belakang dengan memberi penjelasan kepada semua calon dari kumpulan data yang berisi 2600 dan juga mengklasifikasikannya ke kelas masing-masing yang dicapai dengan menggunakan Uji Akumulasi Nilai Tunai (CVAT). Fail anotasi digabungkan dengan gambar asli dan diproses terlebih dahulu menggunakan Roboflow. setelah memuat naik set data, Roboflow menghasilkan pautan yang akan digunakan di Google Colab untuk mengimport set data untuk tujuan latihan untuk disahkan dan diuji lebih lanjut. Algoritma yang digunakan untuk pengesanan dan pengecaman objek adalah algoritma YOLOv5 Penilaian kaedah yang digunakan diuji oleh 100 bingkai per kelas. Eksperimen ini menghasilkan tahap pengesanan dan pengiktirafan yang sangat baik yang mana sistem ini dilatih.

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LIST OF SYMBOLS AND ABBREVIATIONS

CVAT - Computer Vision Annotation Tool

OpenCV - Open Source Computer Vision

Google Colab - Google Colaboratory

YOLO - You Only Look Once

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Traffic light control systems are widely used for the purpose of monitoring and controlling the automobiles flow through the junction of many roads. Smooth motion of cars in the public transportation routes is the aim of invention and installation of the traffic light. Besides, the main traffic light system consists of three bubbles such as the figure 1.1 below. Where each one of them gives a different signal of action for the drivers to do. Such as, yellow color to slow down, red to stop moving, and green to move to the desired direction. For more convenience of cars motion, most traffic light are supported with arrow direction to reduce the heavier side of traffic jam.

However, most traffic light are also supported by one other crucial factors to ease the movement of cars on roads especially the junction roads at crowded cities, that factor is the countdown timers where it displays the remaining time for the current process of the traffic light. And since traffic light have officially become the main controller of cars movement all over the world, drivers in rush would not slow the speed when it is yellow color, instead they try to catch up. Moreover, errors and overloads of the traffic light have a high possibility to appear and hence accidents of both fatal and casual would have a rise of numbers.

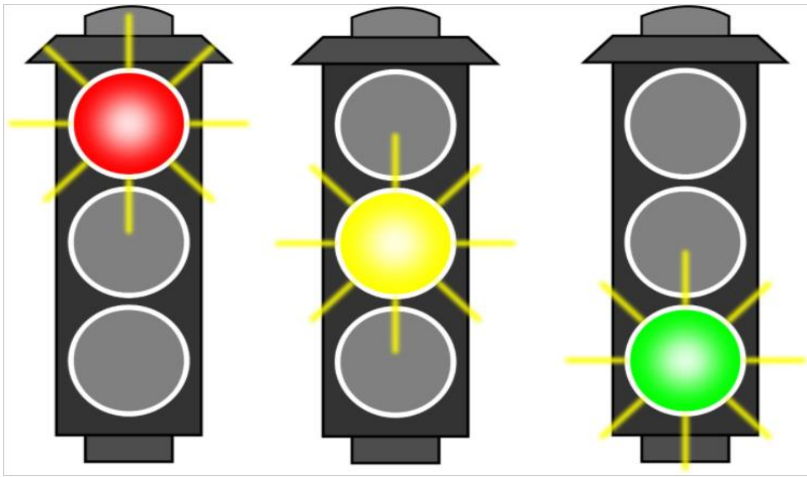

Figure 1.1: The Three Different States of Traffic Light.

1.1 Background

Traffic light countdown timers, or TSCT, is simply a digital number which is displayed on a plate hold right next the bubbles of traffic light. They are used to alert drivers to slow, stop or move based on the current presented light indication on the traffic light. Figure 1.2 below shows a real example of a countdown timer, which indicate the remaining seconds on a red color situation.

Figure 1.2: Countdown Timer on Traffic Light.

Countdown timers are not used at the vehicles phase only; they have also been implemented to control the pedestrian walking phase. The countdown timer of pedestrian has recorded significant positive results since they have been approved in 2003 by the MUTCD. Hence, they have been constructed in all roads which include pedestrian walking line to ease and safe the process for walking people to cross the roads in a confident manner. Figure 1.3 below show a real example of a pedestrian countdown timers.

Figure 1.3: Pedestrian Countdown Timer

Intelligent transportation can be defined as the vehicles ability to operate in an automatic way in order to control the motion direction, speed and to interpret with the outside atmosphere. Therefore, the need of using a great technology would definitely create the chance of improving the level of intelligent transportation. Exchanging good expertise and technology between advanced countries would increase the opportunity of developing a better smart system of vehicles [1].

Hence, the approach of image processing has been studied for many years to accomplish the idea of intelligent vehicles and to offer a great experience of safety. It is also meant to be for achieving the industrial revolution 4.0 demand. By implementing vehicles with the technology of image processing, the automation field would have a great improvement and that would also be useful when applied to automating vehicles where drivers can have plenty of important data provided such as warning of any incoming danger or help to avoid crashes. Automation of vehicles havee a good accurcy and safety, an example of that is when an automated vehicle can park in a narrow parking where the driver door would not have space to open, the vehicle then could also switch on and move out from the parking when needed.

However, the image processing method can be defined as a method which is used to get an enhanced image or to extract some important information. Two type of image processing are used by different algorithm. Such as, digital image processing which is an analysation on a digital image done via computer algorithm. On the other hand, analogue image signals which is a form of two-dimensional signal and can only be manipulated by an

electrical signal. The procedure used by image processing to result the desired output is done by using engineering tools such as a camera for capturing the image at the first place. The captured image then would have to go under multiple processes to achieve the goal of this technology.

1.2 Motivation

Traffic light countdown timer detection and recognition would definitely create a smarter system for vehicles to provide a better safety features together with the idea of intelligent transportation. Countdown timers are a technology which is used to make an arrangement and smooth flow of vehicles at crowded pre-timed intersections. However, the technology of autonomous vehicles is expanding and therefore the detection of traffic light and recognition of countdown timer is getting advanced too due to the interconnection between them.

The traffic light countdown timer provides theoretical benefits for the community and the environment. For the community side, the benefit would come by the time spent while waiting for the traffic light to turn to green, where drivers could switch off their vehicles to save the fuel especially in the main intersection where it takes long time. Moreover, the benefit for the environment would be done by reducing the pollution when derivers decide to switch off their vehicles while waiting.

1.3 Problem Statement

Countdown timer recognition of traffic light is an important and a major factor to improve the safety on the intersections of public roads and facilitate the decision makings for drivers when they are reaching intersections. However, detecting the countdown timer is considered as a part of ADAS (Advanced Driver Assistance System). ADAS is a technology used in vehicles which helps drivers for driving. ADAS is required to be implemented in vehicles for the purpose of providing guidance for drivers and enhancing a better safety for vehicles and roads by minimizing human error which often occur at roads intersections.

Meanwhile, countdown timers of traffic light which are made up to warn drivers about the time remained for the current state shown on one of the three bubbles on the traffic light. However, recognition of the countdown timer of traffic light provides an input to the system of autonomous vehicles technology of the remining time on the traffic light in order to have a more accurate system in term of controlling the vehicle's speed.

1.4 Objective

The objective of this project are:

a) To design a vision system to detect traffic light with counter.

b) To develop a vision system to recognize the counter of the traffic light and the presented color.

c) To analyze the performance of the algorithm for the traffic light counter detection and counter recognition.

1.5 Scope

1) Detecting and recognizing the number of traffic light from Nine to Zero.

2) The color of traffic light specified green and red.

3) Detecting and recognizing the countdown timer of traffic light during day time only.

4) Analysis parameters of the performance are the object detection rate and accuracy of the network by using confusion matrix.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of image processing

The method of image processing is used to perform some operations on an image for the purpose of getting an enhanced image or to extract some important information from the image. Image processing is a signal processing which requires an image as an input and that produces on the other side image or data needed from the extracted image. However, image processing is currently becoming one of the technologies which are rapidly growing and spreading its boundaries in engineering research as well as computer science. One of the goals of image processing technology is to increase the safety side and decrease the number of vehicles crashes especially in the future where the autonomous car driving would be widely used [2].

Generally, image processing could be summarized up to three steps. Firstly, the image needed to be imported using either real-life detection or as a recorded video. Secondly, the imported image would have to be analysed and manipulated for the aim of having the wanted data and information. And lastly, the output result can be presented as a chart or a graph to display out the analysed data in an easy and understandable way. The data then can be improved further.

Analogue and digital methods are the two types used for image processing. Analogue method of image processing is used for hard copies such as printouts and photography. On the other hand, digital image processing is mainly used by computers to help in manipulation of the digital images. By the data which use digital technique have to undergo three phases which are pre-processing, enhancement, and display information extraction. Figure 2.1 below illustrate the digital image processing procedure. Where the input image has to be

acquired before it goes to the pre-processing then a loop which started with feature extraction, associative storage, comparison, and lastly knowledge based. However, analogue image processing is shown in figure 2.2.

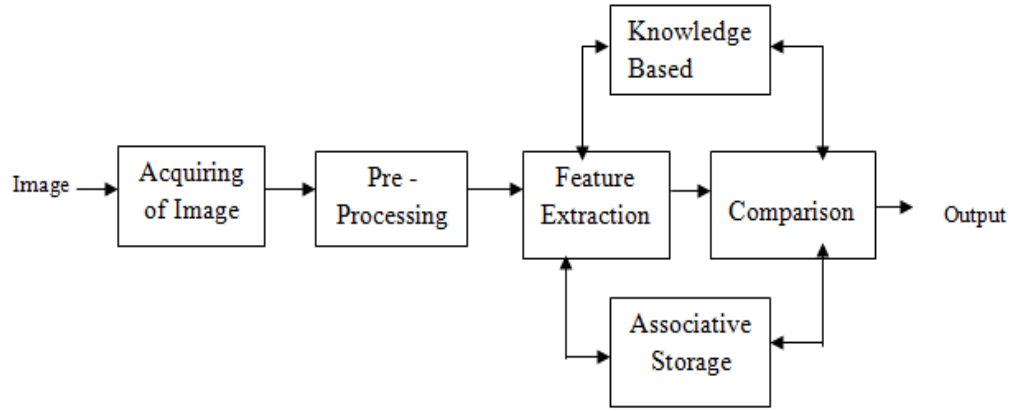

Figure 2.1: Digital Image Processing

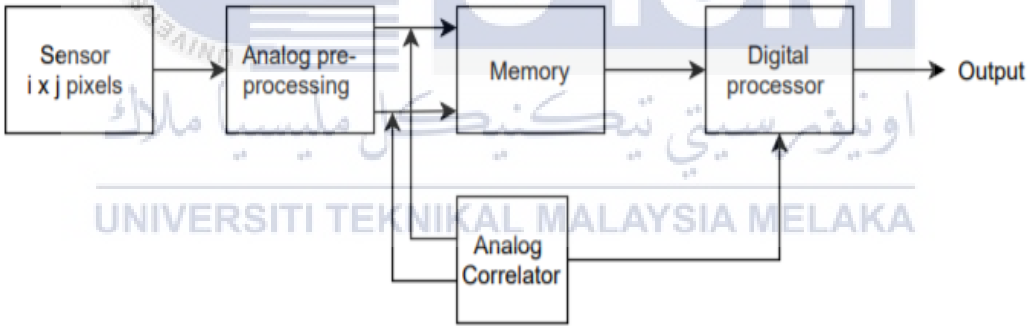

Figure 2.2: Analogue Image Processing

2.2 Real Time Recognition of Traffic light with Count-Down Timer

Traffic scenes include lot of information which makes it difficult for drivers to constantly keep attention on traffic signs. As a result, some traffic data or signs may be missed due to a variety of factors, including the intricacy of the road scene, the abundance of visual information, or even the driver's stress or visual tiredness. However, Driver Assistance System has recentaly been developed to provide information of trafic signs, traffic light, speed limit, ect [3].

Detection of traffic light can be done using several methods. Detecting traffic light by using the information of the color and the shape of the traffic light is one of the famous methods used [4]. As a color information, the detection process starts with normalizing the input image using color space conversion. However, Sobel filter was used in [4]to obtain the edge information. Hough Transform purpose was to verify the circle of the traffic light. But because of the discontinuities in the light surface, the proposed method may not be suitable to LED traffic lights.

The digits on the timer display are recognized using approaches based on the connected components methodology [5], which includes developing a real-time display detector and a digital character recognition application.

In the presented work [3], the method used for detecting traffic light is by color segmentation. In order to perform the color segmentation, the threshold approach is used. Thresholding is a process which offers an easy way for performing segmentation on the background region of the image. It is used to find in which area of an image contains pixels which lie within a specific range. Considering the three color of the traffic light red, yellow, and green where every one of them has its own range of intensity value and that would determine the desired pixels to be detected or ignored [6].

To detect the traffic light color, two steps are used. First is to state the thresholding for Red, Green and Blue where the outcome is a result of a comparison done between the three colors. For instance, if the chrominance of Red > 250, chrominance of Green < 50 and chrominance of Yellow < 50 then the result is a Red light. Yellow would result when Red >

250, Green >200 and Blue < 150. And when Red < 50, Green >50 and Blue > 200 the light would be Green.

For the digit of the countdown timer to be recognized, the image has to be segmented and extracted in the first place. Once that is done, the image would be scanned to find any of the three colors, when it finds one color of the three, the entire row would be selected and stored as a variable as can be seen in Figure 2.3.

Figure 2.3: Horizontal Scanning for detecting digit based on color [3].

The next step is to obtain the digit only from the previous saved image. In order to do that, the image has to horizontally and vertically scanned. As a result, the digit would be the only area selected as shown in figure 2.4.

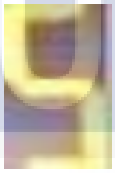

Figure 2.4: Segmented and Extractd digit [3].

At this point, the digit has not been recognized yet, it has been prepared to identify the digit that the image contain. However, the process used by to recognize the digit is divided to six steps. Starting with resizing the segmented image, extract channel components of red, green, blue, convert the image to binary, bounding box on the digit using (x,y) coordinates, after that the value of the binary image would only be either a one or a zero where each digit has its own binary number to be recognized. Table 2.1 shows the seven LED segments with their corresponding on/off status.