Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF AUTO CONTROLLED TRAFFIC LIGHT USING MACHINE LEARNING

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Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

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Supervisor Name : RADI HUSIN BIN RAMLEE

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DEDICATION

To my beloved mother, father, my family,

and

To respectful project supervisor, friends and

My housemates.

ABSTRACT

As the city's population and automotive traffic grow, traffic congestion at intersections is becoming a significant issue in many large cities. The inefficiency of the existing traffic light system's approaches and algorithms is one of the causes of the traffic issue. Therefore, adopting new systems and technologies capable of improving the current traffic light control system is urgently needed to prevent the situation from worsening. This project proposes an automatically controlled traffic light based on the machine learning technique. The concept used to develop an auto-controlled traffic light that be control the traffic congestion. The system was developed on two lanes of a four-legged intersection with a turning signal. By using a machine learning technique, a reinforcement learning algorithm, the system aims to providing the optimal traffic light phase and adjusting the timing of the green phase, depending on vehicle demand. Furthermore, vehicle demand was measured by an induction loop sensor implemented on the road along the intersection. Based on the simulation result, the proposed system be able to altering the green light duration and providing a suitable traffic light phase sequence based on the road congestion compared to static traffic light, which has a fixed green light system and traffic light phases.

ABSTRAK

Apabila populasi bandar dan lalu lintas automotif berkembang, kesesakan lalu lintas di persimpangan menjadi isu utama di banyak bandar besar. Algoritma sistem lampu isyarat sedia ada yang tidak cekap merupakan salah satu punca berlakunya isu lalu lintas. Oleh itu, penggunaan sistem dan teknologi baharu yang mampu menambah baik sistem kawalan lampu isyarat semasa amat diperlukan untuk mengelakkan keadaan menjadi lebih teruk. Projek ini mencadangkan lampu isyarat terkawal automatik berdasarkan pelaksanaan teknik pembelajaran mesin. Konsep yang digunakan adalah untuk membangunkan lampu isyarat kawalan automatik yang dapat mengurangkan trafik congestion. Sistem ini dibangunkan pada dua lorong persimpangan empat kaki dengan isyarat membelok. Dengan menggunakan teknik pembelajaran mesin yang mengunakan algoritma pembelajaran pengukuhan, sistem ini menyediakan fasa trafik yang optimum dan melaraskan masa fasa hijau, bergantung pada permintaan kenderaan. Tambahan pula, permintaan kenderaan diukur dengan penderia gelung aruhan yang dilaksanakan di jalan di sepanjang persimpangan. Berdasarkan keputusan simulasi, projek ini dapat menyediakan fasa trafik yang optimum dan melaraskan masa fasa hijau berbanding dengan lampu trafik statik yang hanya menyediakan tempoh lampu hijau dan susunan fasa lampu isyarat yang tetap.

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m	-	Meter
s	-	Second

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CHAPTER 1

INTRODUCTION

1.1 Background

There is no doubt that traffic congestion is a major problem in today's society, and the problem is worsening. Many factors contribute to traffic congestion, including a rapidly growing urban population, an increase in the number of cars on the road, ineffective government road construction and management, and, in particular, an traditional traffic light system that is unable to keep up with the growing volume of cars on the road.

In Malaysia, traffic lights are widely seen as traditional traffic lights that use fixed time signals and some actuated traffic lights in developing cities. While in some metropolitan locations, traffic light management systems equipped with countdown timers have been shown to increase traffic safety by enabling drivers to make more informed and safe traffic judgments depending on the remaining time on a red or green light. Even though numerous features have been added to the standard traffic light system to increase traffic flow efficiency, these systems are still hardwired at the time of installation, which means that most of them are pre-programmed for a specific length for each signal change. Due to the limited ability to control the high traffic density in urbanised regions, these conventional traffic light control systems will eventually become critical sources of various traffic concerns. In this case, the project concentrates on reducing road traffic congestion by implementing the proposed system.

1.2 Problem Statement

Nowadays, many nations, including Malaysia, suffer the negative effect of traffic congestion, which influences the resident lifestyle in urban communities and negatively impacts such as lost time, wasted fuel, and increased vehicle maintenance costs.

The traffic congestion issues arise due to a variety of problems. The first problem is peak hour congestion. At certain lanes, the amount of traffic has increased significantly before and after work hours, but the conventional traffic light system still provides a fixed duration of green signal to the lanes that have congestion and the lanes that are free of vehicles; as a result, it causes peak hour congestion.

The next problem is timing for empty roads. It is possible to have a traffic light that shows green even if there are no vehicles on a particular intersection. To put it another way, the current traffic light system is pre-programmed, and road users must wait for the signal to change from red to green, which wastes their time.

From the problem given, this project will provide a solution to solve the problem mentioned by developing the proposed project is auto controlled traffic light using machine learning.

1.3 Project Objective

The main aim of this project is to propose a traffic light system that achieves the project objective below:

a) To develop a traffic light system that automatically controls traffic flow based on machine learning techniques and sensor implementation.

b) To provide optimal green light duration and traffic light phase based on traffic congestion.

c) To develop traffic congestion prediction using the machine learning technique.

1.4 Scope of Project

The scope of this project are as follows:

a) Restricted to a two-lane of four-way intersection with one turning signal.

b) Limited to twenty-four sensors of induction loop, making each lane have six maximum of sensors.

c) Machine learning model use reinforcement learning which utilised the neural network and deep Q-learning as framework.

d) Simulation of Urban Mobilty (SUMO) is used as traffic simulator with car's input to 1000 and 3600s simulation time.

e) Simulation only involves car vehicles on the road network and each car has the exact physical and speed specifications.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section covers the review of literature on crucial project topics. A literature review's purpose is to describe the knowledge and ideas that have been created on a particular topic, as well as their strengths and limitations. Before beginning this study, a literature study was undertaken to gather information on the technology available and the methodologies used by other researchers working on the same topic throughout the world at the same time.

2.2 Overview of Traffic Light System

Traffic signals are intended to maintain an orderly traffic flow, provide a safe crossing for pedestrians and cars, and reduce confrontations between vehicles approaching intersections from different directions. Based on [1], traffic lights are classified into three types: static, actuated, or adaptive.

Fixed-time or static signals operate in a predetermined sequence, allocating the same amount of time to each traffic movement regardless of whether traffic is present [2]. Actuated traffic lights set the length of each phase based on a fixed cycle length; thus the split plan changes based on the traffic coming and going [1].

The adaptive traffic light can adjust the signal timing parameters in real-time in response to the manager's management objective (such as the intersection's minimum delay) and the arrival characteristics of the traffic flow at the intersection[3] . However, as the year is growing, there is a new type of traffic light system called intelligent traffic light control.

The goal of an intelligent traffic light control system aims to reduce traffic difficulties, such as traffic congestion or traffic jams at intersections, by combining current traffic technology with artificial intelligence. Instead of the traditional traffic light control system, where everything is controlled manually with a fixed green light sequence and fixed duration, the system will eventually be able to think for itself and take action regarding the sequence and duration of green lights to reduce and prevent traffic congestion [4].

In this project of development of auto control traffic light system using machine learning, the system will be under intelligent traffic light type which the system aims to adjust the green phase timing and also give ideal traffic phase in real-time to minimise the waiting time of traffic flow at intersections by using artificial intelligence.

2.3 Literature Review of Related Works

[5]propose an intelligent traffic control system that uses two-way communication based on LED visible light communication. Moreover, the system is able to obtain a large amount of data such as vehicle access and status, the vehicle's speed history and the access right. The system includes the vehicle's LED head and taillights, the photoelectric or image sensor, and the control station as the receiving end. The light connects the vehicle and the control station. It connects with the control station first, then with the control centre through cable or optical fibre. For example, good footprints, access rights, vehicle status, historical speed, dynamic, and high data volume are all sent to the vehicle by the control side (control centre and station). The vehicle then provides data to the control side. In the system, machine learning is used to determine the colour properties of a visible light source in various situations, and then the training model is used to predict the light source's colour.

[6]present a GSM-based Intelligent Traffic Control System which is used to reduce traffic congestion. The IR sensors are used to calculate vehicle density. The microcontroller

controls the traffic light signals based on vehicle density. Vehicles can also change routes if heavy traffic is detected on the existing route through GSM. The system uses GSM to send the collected data from the sensor to the controller, and the controller makes a decision based on the data collected.

[7] developed an intelligent traffic light control using Collaborative Q-Learning Algorithms. This proposed work aims to reduce waiting time at traffic lights using collaborative Q-Learning as a reference model for real-world traffic congestion solutions. Based on the results, Collaborative Q-Learning Algorithms can be concluded as the best traffic light control algorithms with a waiting time of 54.67 seconds. Furthermore, Green Light District Simulator is used to simulate. The optimal settings for the Collaborative Q-Learning algorithms approach are one learning rate and 0.8 discount factor. The primary reward method results from subtracting the waiting time before and after.

[8] propose an intelligent traffic light control system using distributed multi-agent Q learning. Using the proposed multi-agent Q learning algorithm, the proposed system aims to optimise both the motorised and non-motorised traffic. In addition, the authors considered many constraints/rules for traffic light control in the real world and integrated these constraints in the learning algorithm, which can facilitate the proposed solution to be deployed in real operational scenarios. Numerical simulations conduct the system for a real-world map with real-world traffic data.

[9] develop crossroad traffic lights by using a fuzzy control algorithm that controls twelve phases of three traffic lanes with a single crossroad traffic light. The proposed system uses an induction loop sensor to get the number of vehicles from each sensor. Then, the phase with the most significant number is stipulated to be the highest priority. At the same time, the phase turns to the next one from the previous; it transfers into the highest priority.

Then, the best green light delay time can be figured out under the reasoning of the fuzzy rule on the current waiting formation length and general formation length.

[10] present an adaptive traffic light control system using wireless sensor networks. The system proposed reducing waiting time at the road network by prioritising the shortest queue of the lane.

[11] shows an Adaptive Traffic Light Control System (ATLCS) that implements GSM technology on the road. The suggested system detects traffic using a network of array sensors. The timing intervals of red and green lights at each road crossing are intelligently calculated and modified to minimise waiting time to a minimum. Thus, optimising traffic light switching increases road capacity, reduces travel time, and avoids traffic jams. The system will also provide additional accommodations for emergency vehicles. The GSM cell phone interface offers drivers real-time traffic information and assists in traffic regulation and alternate route selection. The suggested system's performance is compared to a fixed time traffic signal control system.

[12] present an Adaptive Traffic Light Controller Simulation for Traffic Management. This system proposes using an agent-based modelling system to control traffic lights, with a particular emphasis on modelling on the unity3D platform and implementing fuzzy logic control. The test was conducted in three conditions: crowded, moderate, and smooth. The average waiting time, the average number of cars stopped, and the average speed of the vehicles is the system performance parameters.

[13] propose an adaptive Traffic light controller that use FPGA to solve the problem of fixed time traffic signal, which always allow the same amount of time for vehicle movement regardless of whether traffic is present. The system is able to detect traffic density and emergency vehicles on individual roads. When an emergency vehicle is detected, that direction's traffic is prioritised. Regular operation of the system will manage the signal based

on traffic density. The system is based on Spartan 3E FPGA and Verilog HDL. This approach overcomes the limitations of standard TLC.

[14] present an Ai based traffic signal control system to ensure seamless car mobility. An Arduino-based system with image processing is proposed for traffic density monitoring. An image processing system regulates signal synchronisation based on vehicle counting at the traffic light. The prior signal controls the next signal. The device is intended to help people caught in traffic. In the system, MATLAB is used to process images from roadside cameras.

[15] develop an embedded traffic control system where the traffic load is continuously measured by sensors connected to a microcontroller-based system. The system is divided into three parts. In the first module, proximity sensors or magnetic pick up based touch sensors detect traffic frequency. The sensor output is first amplified, then digitally translated to interact with the microcontroller. In the second module, a programmed embedded processor decides the traffic signal delay based on traffic frequency. The third module connects the microcontroller's ports to traffic lights.

[16] present the practical application of programmable logic controller that controls real-time intelligent traffic lights. A traffic junction with associated signalling was created to meet these requirements, and an intelligent traffic light controlling system was implemented. In the system, SIEMENS, SIMATIC S7-300 PLCs were employed to complete this task, which monitors and supervises the entire system's operation via sensors.

[17] develop a traffic light control based on Fuzzy Inference Enabled Deep Reinforcement Learning which use real-time traffic data to alter the length of traffic lights. The proposed system has three modes: Fair Mode (FM), Priority Mode (PM), and Emergency Mode (EM), where all cars have equal priority, specific categories have varied levels of priority, and emergency vehicles have the highest priority. The system uses a deep