Faculty of Computer Science and Information Technology

A SIMULATION ON TRAFFIC LIGHT CONGESTION

Abdul Khalil Bin Japar

**Bachelor of Computer Science with Honours
(Network Computing)**

(2020)

A Simulation on Traffic Light Congestion

ABDUL KHALIL BIN JAPAR

This project is submitted in partial fulfillment of
the requirements for the degree of
Bachelor of Computer Science and Information Technology

SUPERVISOR: PROF. MADYA DR TAN CHONG ENG

Faculty of Computer Science and Information Technology
UNIVERSITI MALAYSIA SARAWAK
2020

UNIVERSITI MALAYSIA SARAWAK

THESIS STATUS ENDORSEMENT FORM

TITLE   **SIMULATION ON TRAFFIC LIGHT CONGESTION**

ACADEMIC SESSION: 2019/2020

ABDUL KHALIL BIN JAPAR
(CAPITAL LETTERS)

hereby agree that this Thesis* shall be kept at the Centre for Academic Information Services, Universiti Malaysia Sarawak, subject to the following terms and conditions:

1. The Thesis is solely owned by Universiti Malaysia Sarawak
2. The Centre for Academic Information Services is given full rights to produce copies for educational purposes only
3. The Centre for Academic Information Services is given full rights to do digitization in order to develop local content database
4. The Centre for Academic Information Services is given full rights to produce copies of this Thesis as part of its exchange item program between Higher Learning Institutions [or for the purpose of interlibrary loan between HLI]
5. ** Please tick (√)

☐	CONFIDENTIAL	(Contains classified information bounded by the OFFICIAL SECRETS ACT 1972)
☐	RESTRICTED	(Contains restricted information as dictated by the body or organization where the research was conducted)
☑	UNRESTRICTED	

Validated by

_____
(AUTHOR'S SIGNATURE)
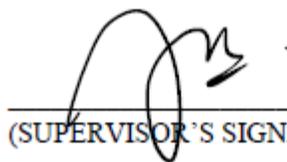
_____
(SUPERVISOR'S SIGNATURE)

Permanent Address

Kampung Somboi,
Kinarut, Papar,
89600, Sabah.

Date: 12 August 2020

Date: 12/8/2020

Note   *   Thesis refers to PhD, Master, and Bachelor Degree
      **   For Confidential or Restricted materials, please attach relevant documents from relevant organizations / authorities

Declaration

I hereby declare that no portion of this thesis has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

_____

Abdul Khalil Bin Japar

Network Computing

Faculty of Science Computer and Information Technology

Universiti Malaysia Sarawak

Acknowledgement

Praised for Allah the Most Merciful and Compassionate for giving me the strength in completing this research and thesis.

First of all, I would like to express my sincere gratitude to my supervisor, Prof Madya Dr Tan Chong Eng for his continuous support, supervision, expert advises, encouragement and patience throughout this important research. His guidance helped me in all the time of research and writing of this important thesis.

My appreciation also goes to my family member especially my parents for their extraordinary support throughout my study. I manage to complete this final year project because of their support, their prayers and their smiles that keep me strong everyday to finish this important year.

Lastly, my appreciation goes to Nurina Asyura Mohd Yunus, as a senior master student in research and my partner, for the guidance and knowledge that have been shared. She always be there for me, even the MCO really did a great impact on this research study and the writing process. She keeps on reminding me about FYP. Thank you for always be there with me and for your constant support.

Abstract

A traffic light is one of the efficient traffics control used to monitor the flow of vehicles. A congestion occurs when the volume of car is high than the road capacity. Other factors that will cause the congestion happened are due to the different driver's behavior and the green time of traffic light that are not optimum enough to support the road demand. This study carry out to evaluate the current traffic light system and set a new standard traffic light signal timing to provide a better proposed system of traffic light. This can be achieved by undergo a simulation using a specific software.

Keywords – traffic light, optimum time, congestion.

Abstrak

Lampu isyarat adalah salah satu kawalan lalu lintas yang cekap digunakan untuk memantau aliran kenderaan. Kesesakan berlaku apabila jumlah kereta adalah tinggi daripada kapasiti jalan. Faktor-faktor lain yang akan menyebabkan kesesakan berlaku disebabkan oleh kelakuan pemandu yang berbeza dan masa lampu lalu lintas hijau yang tidak optimum untuk memenuhi permintaan pengguna. Kajian ini dijalankan untuk menilai sistem lampu isyarat terkini dan menetapkan masa isyarat lampu isyarat ke standard baharu bagi menyediakan sistem lampu isyarat yang lebih baik. Ini boleh dicapai dengan menjalani simulasi menggunakan perisian tertentu pada masakini.

Kata kunci – lampu isyarat, optimum masa, kesesakan.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Introduction

At present, with rapid development of economy and technology the uses of vehicles have increased dramatically. This will eventually lead to traffic congestions due to several factors. Those factors are; more vehicles than the road can accommodate, bottleneck effect such as on- ramps, road traffic crashes and construction work (Ackaah., 2019). Although some of the problems can be resolved by undergo few construction, space and economy constrains might be the limiting factor for every expand traffic demand. Thus, the uses of traffic light have been employed for years in order to control the traffic flow

The first traffic control was installed on 9th December 1868 and was controlled manually by human (Grandinetti., 2018). According to Kamran and team (2017), there are two main types of traffic lights which are the pre-timed traffic lights that work on constant time interval and traffic actuated light that use cameras and electronic sensors to access traffic volume accordingly. However, high traffic volume on the street would demand the appropriate timing in traffic lights cycle. In fact, the traffic lights timing has attracted researcher who deal with traffic management problems and searching for practical solutions without undergo road construction such as roundabout and fly-over. With appropriate solution and methodology, this project will be conducted by using matrix laboratory (MATLAB) to evaluate the current traffic light system.

MATLAB is a numerical computing environment and a fourth-generation programming

language with allow plotting of function and data, creation of using interfaces and implementation of algorithms (Gupta et al., 2013). Thus, the graphic and simulation design of MATLAB will convert digital signals from traffic flow at intersection that can control traffic light delay. Therefore, with the development of computer and image processing technology, vehicle flow detection based on image processing technology has become the trend of vehicle flow detection technology because of its advantages of large coverage, abundant detection information, convenient maintenance and simple installation (Nie., 2018).

1.2 Problem Statement

Traffic light system has been widely used for traffic coordination at road intersections. It also serves a function to ensure fair access and to reduce traffic congestion under overwhelming traffic volume.

Even with traffic light implemented, severe congestion still occurs as traffic volume increases. The fair access implemented by the conventional traffic light system does not work too well under heavy traffic situation. This severity of the congestion may have been influence by the duration of the green light and the number of cars that can pass through the traffic light for every green light. The driver behaviors may also a factor causing congestion at the traffic light. This has brings the need to evaluate and conduct proper research to optimize the green light delay by using technology in which could be the future solution of this problem.

1.3 Scope

This project is done to seek the possibility to further optimize the green light duration for achieving optimum number of cars passing through the traffic light. In addition, it is focusing to achieve a higher number of cars pass through per minute in order to ease the traffic congestion at the traffic light. Lastly, it will need to take into consideration of adequate observation on the queue length at each direction in which later could optimize the green light duration.

1.4 Objectives

1. To evaluate the performance of current traffic light system.
2. To propose an optimization for green light duration to maximize the output (number of cars per minute) of the traffic light system in order to ease traffic congestion at the traffic light.
3. To benchmark the proposed optimization to a conventional traffic light system.

1.5 Brief Methodology

A research methodology is a method used to successfully achieve all the researchs objective and solved the research problem systematically. This research-based project will use qualitative research method. Qualitative research is a scientific research that was used to seeks answers or solve the problem statements with a set of procedure.

Research Background

Data Collection

Data Analysis & Simulation

Result and Documentation
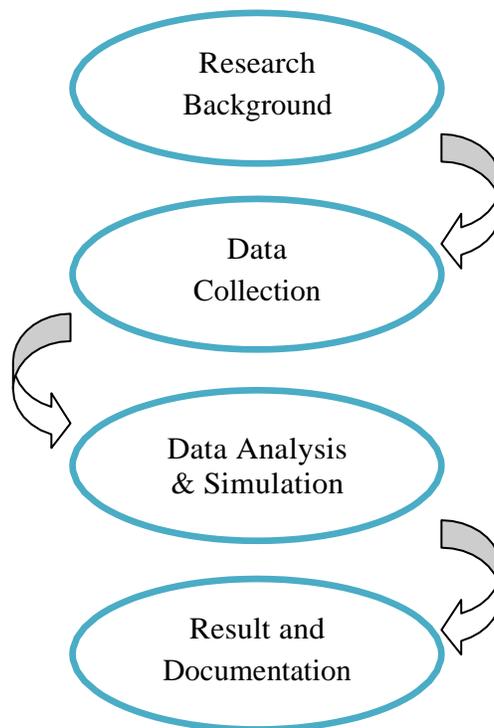
Figure 1: Series of brief methodology

1.5.1 Research Background

In phase 1, a discussion is made with the supervisor to identify the requirements that needed in this project in order to conduct the experiment in research-based methodology and project.

1.5.2 Data Collection

All the data need to be collected in order to evaluate the current traffic lights. In this phase, the data is collected by observing the time of traffic signals and the maximum number of cars that passed through the traffic lights. Then, the data will be listed into a table to be observed and analyze for research purposes.

1.5.3 Research Experiment

Phase 3 is where the data is analyzed by comparing the time taken of the traffic signals and the number of cars that passed through the traffic lights per minute. This experiment will be conduct by using MATLAB application. Through MATLAB graphics and processing, the traffic flow is converted into digital signal in which the data collected will be used for simulation design of intelligent traffic light. These will be used in order to get the optimum number of cars that can passed through the traffic lights in an optimize duration of traffic signals.

1.5.4 Result and Documentation

In the last phase, the data will be collected and compared within two situations; during peak hour and during standard hour. In which taken into consideration are the traffic lights time taken, car pattern and the queue length of cars at the intersections. Data will be used in MATLAB simulation design, in which the output will be documented for the research-based purpose.

1.6 Significance of Project

Limited land resources and high demand of private vehicles uses has led to ever growing traffic congestion problems. However, suggested method may have been proposed to discuss on simulation that can be done to counteract this problem. Technology such as MATLAB will be used for graphics and image processing to monitor the traffic flow at the intersection in which will be converted to digital signal (Nie., 2018). Vehicle flow will eventually tell the usual delay at the traffic light. Thus, this project could exert huge significance towards the society and the research field itself.

1.6.1 The Significance towards Research Field

- Present and enhance the using of MATLAB in simulation projects.
- Provide new information for future researcher in designing an intelligent traffic lights system.
- Upgrade conventional traffic lights system into future intelligent system.

1.6.2 The Significance towards Society

In term of economic and time

- May reduce the use of high budgets and space to expand road infrastructure and construction.
- Significant reduce in congestion may reduce time taken in queuing, increase travel times and overcome multiplied gasoline wasted.

In term of health:

- Reduced life-threatening incident due to psychological stress and a rash driving act to make it for the red light running.

- Overcome frustration and in justice feeling of driver due to short or long traffic cycle length.

1.7 Chapter Outlines

This chapter examined problems that mainly took place at the traffic light which lead to high severity of congestion such as inefficiencies of traffic light green time duration and driver behavior which will affect the queuing delay. Thus evaluation on current traffic light performance is crucial in optimizing traffic light operating duration for higher throughput. Since the vehicle flow can be considered as a factor telling the delay occurred at the traffic light, this study have bring significance important to the society and also for the research field. Comparison of proposed optimization idea with the conventional traffic light system is also important in tackle out the problems.

Chapter 2: Literature Review

2.1 Introduction

This chapter will discuss about the literature review for traffic light simulation that have been made by researchers towards the traffic light system and the flows of cars at the traffic light intersections. These writing of literature review can be clarified as the process of reading, analyzing, evaluating and summarizing the conventional technique of simulation which is related to the case study.

There are many researchers modeled and developed the simulation on traffic light behaviors at the intersection which are used in the current system of traffic light. However, there are some requirements that are not highlighted in order to fulfill the user needs. The traffic systems are not ready to face the demand of green light utilization together with the congestion happen at the traffic lights.

In this chapter, the various technique of traffic light simulation is described in the following section. This chapter begins with the background of research study, reviews on existing technique and followed by the comparison on all reviewed technique.

2.2 Background

Various campaigns have been conducted together with upgraded laws that might be useful to be practiced on the road, all for the safety reasons of the road's users. Although, the frustrations itself on the road cannot be helped with an existing law. In fact, most frustration occurred either by the long queue of cars on the road or delay time taken of travel. From my view this might be occurred due to the congestion that mostly took place at the traffic light, which mean to say the intersections.

Traffic lights offer maximum control of movement of cars, it tells the drivers what to do with the different color cycle. Each colors signal tells the movement of heavy flows by assigning the traffic alternately to various movements of routes. In my point of view, the alternate fixed time of traffic light, will be identified later for sure as one of the cause of excessive delay due to the fixed time allocated in the traffic signals.

Thus, new traffic technology needs to be study and evaluate with much improve efficiency for a properly timed, designed and located. Taking into account of the traffic light functionality in handling heavy capacity at allocated intersections in order to make sure continuous movement of traffic is possible at a specific speed in particular route. This research will be beneficial in getting optimum green timed with maximum cars number, which later set a benchmark to conventional technique.

2.3 Reviews on Existing Techniques

The flow of cars on traffic lights intersection can be control by several types of traffic light systems. With a given optimization on green time traffic lights signal these systems create an opportunity to reduce the congestion on traffic lights intersection from the conventional traffic lights to the current traffic lights technology. These reviews will be looking at the types of traffic lights, the conventional technique of simulation for traffic light reviews and the simulation technique that will be used.

2.3.1 Types of Traffic Lights

There are two types of traffic light system which are the pre-timed traffic light system and the actuated traffic light system. Pre-timed traffic light system provides a repetitive cycle and split timing in which the timing is repeated over and over regardless of the presence or absence of traffic demand (Gartner, 2013). When operating as part of a system, adjacent intersections operate on the same cycle length and have fixed offsets. Pre-timed traffic light control is based on the old version of traffic pattern which is the length of time interval in the cycle are fixed for each signal indication and the split timing of each intersection is assign in predetermined schedule. According to Kwatirayo and team (2013), conventional traffic light signal with fixed or pre-determined variable cycles setting can alleviate the increasing traffic problem especially with continuously growing vehicular traffic in urban areas. Thus, the pre-timed traffic light system is not suitable to be applied at a rapid growing area due to drastic increase of cars queuing and the fixed timing cycle of the traffic light system.

Generally, actuated traffic light system is divided into coordinated and non-coordinated (isolated) system. According to Brian and the team (2010), coordinated actuated traffic light system performs better than the isolated systems. Actuated traffic light system operates

independent of any other traffic control signal where it requires detectors for all the phases with each phase timed according to preset parameters (Gartner, 2013). An actuated traffic light system is used at the intersection to facilitate smooth progression in response to traffic volume variations caused by unpredictable and shifting traffic distribution. Furthermore, to compare the pre-timed traffic light system, actuated traffic light system is more flexible due to its ability to respond to the cycle-by-cycle variation of traffic volume to unnecessary delays and stops. Thus, in my research, actuated traffic light system approach might be use since it can give an optimum green time split on the traffic light.

2.3.2 Conventional Technique of Simulation for Traffic Light Reviews

Many simulation techniques have been implied by researchers around the globe in order to solve the problem that mainly occurs at the traffic light. The simulation themselves highlighted on various objectives for the smoothness of flow on the road. Here are some reviews on simulation techniques that have been done by using different software and applications.

2.3.2.1 Arena simulation software

Arena simulation software is a tool that are used for modeling traffic light queuing in order to overcome problems such as vehicles long waiting times, slow vehicles movement, and matters that decrease the smoothness of traffic flow. Congestion or traffic chaos usually might occur at the three-stroke and four-stroke cycle light, in which to say at the intersection. The Arena software is capable in developed and validated the modeling behavior of the traffic light that has the same characteristics as the observation made. An example of simulation model for four-stroke intersection in Arena software simulation is shown in the figure (1):
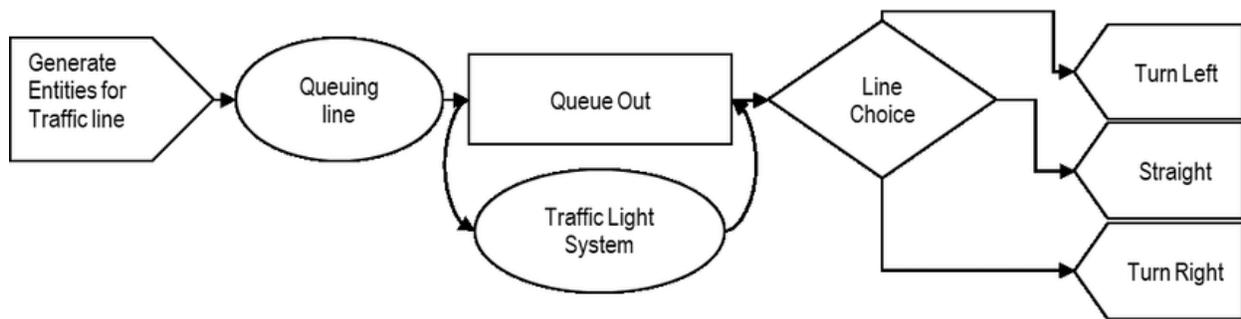
Figure 2: Arena software simulation model from Yuniawan and team (2018)

Besides, there are few implemented parameters that need to be considered in this simulation model. Those parameters are the direction of vehicles, the considered lane and the estimated average time taken for car to start moving. The conducted study on the traffic light timing at the intersections had also been modeled by the team the suggested model is shown in figure (2):
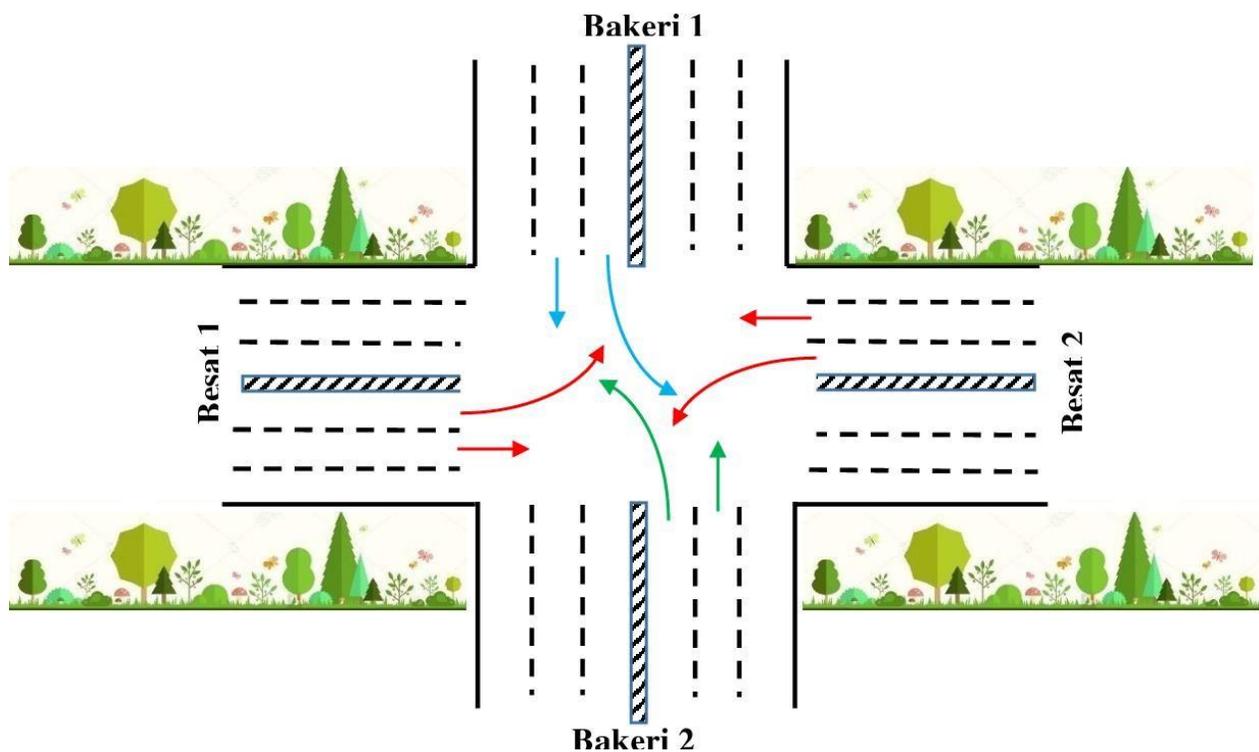

Figure 3: Simulation model on Arena software from Kamran and team (2017)

From the figure above, the straight movements and left-turning vehicles in Bakeri1 streets are allowed (indicated by blue arrows) but any other movements are not permitted. Then, the light

becomes green for straight and left-turning movements of vehicles in Bakeri2 streets (indicated by green arrows) but it is red for all directions of other streets. Finally, straight and left-turning movements of vehicles in Besat1 and Besat2 streets are permissible simultaneously (indicated by red arrows) but it is prohibited for all directions of other streets (Kamran et al,2017)

2.3.2.2 Fuzzy Intelligence Traffic System

In addition, another traffic system for signal timing controller is known as Fuzzy Intelligence Traffic System (FITS). The original idea of the FITS controller was to mimic human policeman in controlling traffic lights at an intersection (Jin et al, 2017). It is a signal controller that contain real-time traffic simulation model embedded for detailed traffic flows. It consists of real-time simulator and fuzzy controller that function in reducing the vehicle delays during heavy traffic volume as an embedded software component in a single board device. The main goal of fuzzy logic in traffic signal control are improving of traffic safety in intersection, maximizing the capacity of the intersection, minimizing the delays, clarifying the traffic environment and influencing the route choices (Adewoye et al, 2015).

Moreover, FITS device capable in providing control decision faster than real time. This is due to the development of the FITS-in-the-loop simulation framework, where the FITS device is integrated with an external high-fidelity microscopic traffic simulator which generates mimicked traffic data (Jin et al, 2017). While, the input and output variables defined the members of fuzzy set having degree of membership that mapped by set of membership functions. In turns, the memberships function set of the fuzzy controller are calibrated in accordance to the traffic flow. According to Jin and team (2017), the queue length can be modeled by the membership function of the fuzzy sets including "zero", "a few", "medium" and "long", as figure (3) below: