An Artificial Intelligence Techniques and Simulation Model to Control a Traffic Jam System in Malaysia (Review Paper)

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ABSTRACT— ***Traffic jam in Malaysia is a huge and complicated problem nowadays, due to the rapid increase in the demand for transportation. This causes a longer vehicle travel times, increased energy consumption, growing environmental pollution, reduced traffic safety, and a decrease in the efficiency of transportation infrastructure. Hence, controlling the flow of traffic has become a very important issue under a growing pressure to relieve traffic jam. In this study, a new Artificial Intelligence Techniques (AIT) and Simulation Model (SM) are applied in order to elicit a general diagnosis for the traffic congestion problem in Kuala Lumpur and Kuantan. An integrated model involves a Neural Network (NN), Fuzzy Logic (FL), Genetic Algorithm (GA), and Simulation Model (SM) is used. The current traffic demand data will be captured by strategically placed cameras. By receiving and processing data, we plan to use our integrated model to adjust traffic lights timing to optimize traffic flow in coordinated traffic lights systems, in order to minimize the traffic congestion through controlling traffic lights. The results of this study will be reported and used to suggest and apply more efficient transportation policies with the aim of providing useful insights on traffic congestion problem, and to assist the Malaysian decision makers to elaborate the best transportation policies.***

Keywords— Transportation system, Traffic Congestion system, Simulation, Artificial Intelligence, Kuala Lumpur, Kuantan.

1. INTRODUCTION

The Malaysian economy is developing so fast, The average GDP growth in Kuala Lumpur in 2010-2013 reached to 10.6%- 7.2% [1]. Most of the people afford to have private vehicles this might causes a vehicle population booming [2].The increase in car ownership has decreased the road network efficiency and increased the traffic jam.

A market research by Frost and Sullivan on 1,227 respondents in Kuala Lumpur – as a one of the most influenced cities by traffic congestion- has revealed that 41% of the respondents ranked traffic jam and congestion as their number one frustrations, higher than Asia-Pacific's average of 35% and global average of 29% [3]

The research has also revealed that 79% of residents depend on private transportation such as cars which is significantly higher than the global average 54%, while 8% depend on public transportation, comparing with 26% the global average; Another 11% use a combination of public and private transportation, while the other 2% are non-motorized, while the global average is 13% for combined transportation, and 8% for non-motorized [4].

In this study, an Artificial Intelligence Techniques (AIT) and simulation Model (SM) will be applied In order to elicit a general diagnosis for the traffic congestion problem in Kuala Lumpur and Kuantan; an integrated model will be applied using, Neural Network (NN), Fuzzy Logic (FL), Genetic Algorithm (GA), and Simulations (SM).

The current traffic demand data will be captured by strategically placed cameras. By receiving and processing data, the integrated model will be used to adjust traffic lights timing to optimize traffic flow in coordinated traffic lights systems, in order to minimize the traffic congestion through controlling traffic lights.

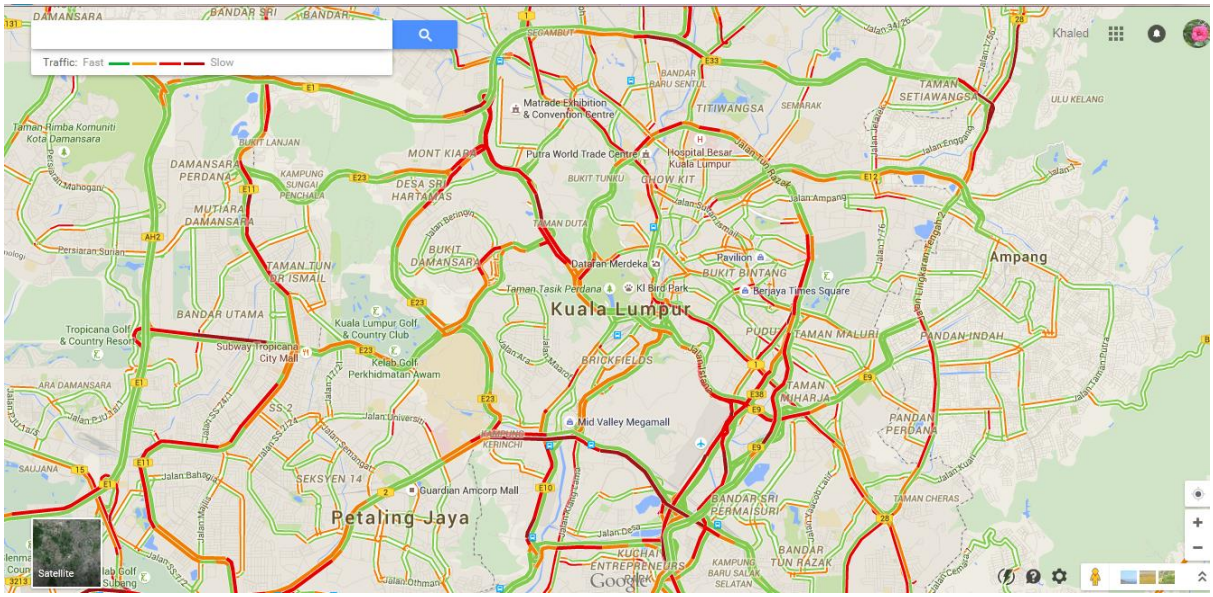
In the current study we expect to apply the new ideas, to enhance the traffic congestion problem, and to assist the decision makers to make the best transportation policies in order to increase efficiency of transportation system, also we expect that this study will help as a guide to organize and develop the road system in Malaysia which can help to avoid traffic jam in Malaysian urban cities..

2. PROBLEM STATEMENT

The main problems which influence the efficiency of transportation in Malaysia are:

- High population growth, the majority of people is using private transportation which may increase traffic congestion **Figure 1**.
- Wasting time of motorists and passengers, because of traffic congestion, which may result in late arrival to all business activities, causing in lost business, or other personal losses.
- Lack of intelligent traffic light in most of urban arias, and lack of good control system for traffic congestion.

The previous problems make the traffic congestion get worse and more complicated in Malaysia.



Source: Google Maps

Figure 1: The road net-work in Kuala Lumpur

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3. THE OBJECTIVES OF THIS STUDY

According to the importance of developing transportation system in as developed country as Malaysia, it is very important to analyze such an activity, in order to find strengths and weaknesses, and to find the best policies that improve the performance and quality of local transport services.

The current study aims to a chive the follows objectives:

a) To identify the traffic congestion problem in Kuala Lumpur and Kuantan.

b) To develop an artificial inelegance techniques in order to solve traffic jam problem.

c) To design an efficient modern at road system in Malaysia, through setting and using a strategically placed observation cameras for collecting an actual traffic data, in order to elaborate an Intelligent Traffic light System.

4. SCOPE

Kuala Lumpur city and Kuantan city are chosen as the study area for assessing the traffic congestion, Kuala

Lumpur is considered as the most affected area by traffic congestion Figure 1 is depicting the road net-work of Kuala Lumpur, which provides data about real time road congestion right on the map. Red color shows bloc way, yellow color shows slow moving, and green color shows smooth flowing.

5. LITERATURE REVIEW

An intelligent traffic light system based on fuzzy logic technology was designed by [5], in order to solve the problems of road traffic congestion in large cities in Nigeria, through monitoring and controlling traffic lights. The authors used Java software for building the simulated version of the traffic control system, the results shows that the system applied provided better performance in terms of total waiting time as well as total moving time. [5] used an edge detection techniques as a one of image processing technique to find traffic density, the method can be applied in MATLAB for regulating traffic light control system based on traffic density, to save the time and to reduce operating cost.

A new approach using Programmable Logic Controller (PLC) technology was proposed by [6], in order to reduce the heavy traffic and congestion on the road, the authors tried to measure the traffic density by counting the number of vehicles in each lane and their weight using weight sensors whose output be fed to PLC which control the traffic diversion, according to this approach, the heavy vehicles take a deferent line than the light vehicles.

A novel traffic signal controller proposed by [7] using Fuzzy logic, two fuzzy layers was used for signalizing the roundabout, in order to improve real-tameness, and to smooth the traffic flows and to avoid traffic jam.

A novel methodology was described by [8] in order to design an inelegant traffic light control system, using image mosaic based design methodology. The data is collected from several CCTV cameras and integrated to match the test image and reference image whose result manipulates the timing of green signal and red signal using decision making algorithm. The approach presented in the previous paper might be very beneficial, as it provides an actual data about traffic density, especially at peak hours. [9] used an Intelligent cameras which connected for capturing real-time traffic flow images of each direction, authors used an intelligent traffic light control algorithm to adjust the traffic light automatically according to the changes of traffic flow in different directions.

[10] used an image processing which measure the traffic density on the road; the cyclic time of the traffic light signals is decided according to the traffic density measurements, the authors used also fuzzy based controller in order to control traffic light timing.

A radio frequency identification (RFID) technique used by [11] to identify the traffic congestion through detecting the velocity of vehicles, and then to control the traffic signal through increasing or decreasing the green signal time due to traffic jam volume.

A telemetry system to monitor and control traffic light intersections in Ghana was presented by [12], the authors used loop detectors to collect data, the data used by traffic light controller, to control traffic light timing.

A mathematical model has been developed representing the traffic control stochastic environment [13]. The authors determined the optimum/near optimal traffic signal timing values through the application of a genetic algorithm that feeds these values into a developed simulation model to obtain the corresponding queuing parameters. The generated signal timings significantly enhance the traffic performance and alleviate the choke points over a multiple-junction urban network. The authors applied the development approach on a network consisting of two consecutive junctions in Alexandria, Egypt using actual field data. The optimization results show that the proposed model can improve the queuing parameters of the vehicular flow.

In the current study we will try to produce a comprehensive study using unique integrated model including: Neural Network (NN), Genetic Algorithm (GA) Method, fuzzy Logic (FL) and Simulations (SMs), in order to investigate and to solve the traffic congestion problem in Kuala Lumpur and Kuantan, which might be helpful for Malaysian decision makers to put in place a sustainable transportation policy.

6. ANALYTICAL METHODOLOGY

In this study, both analytical and quantitative approaches are utilized. The analytical approach is utilized to analyze the performance of the Malaysian traffic system. The quantitative approach is used within an integrated transportation model framework utilizing the Artificial Intelligence Techniques and Simulation Model.

6.1 Artificial Intelligence (AI)

Artificial intelligence (AI) methods have been frequently employed to solve complicated control and. A

wide range of AI methods have been introduced into this area to develop innovative traffic control strategies and fine tune signal timing plans and parameters. These AI applications can be summarized into the following three categories and detailed in the remaining of this study: neural networks (NN), fuzzy systems (FS), and Genetic Algorithm (GA). An introduction to these AI methods is given below **Figure 2**.

6.1.1 Genetic Algorithm (GA)

Genetic Algorithm is an evolutionary algorithm. Some researchers have used GAs to improve traffic light configurations. a new architecture for the optimization of traffic light cycles in a traffic network has been presented by [14]. The model is based on three basic design items: the use of genetic algorithms as an optimization technique, the use of cellular automata simulators within the evaluation function, and the use of a cluster as a parallel execution environment for this architecture. [15] presented a feasible methodology to determine whether or not it is useful to use traffic signals within round a bouts .they have simulated a generic traffic circle including a set of traffic signals placed in it using Genetic Algorithm (GA). The number of traffic signals contained in the traffic circle under study is supposed to be "N Stages"; the chromosome encoding consists of the state of every traffic light, at every step of the fixed period. There are allowed only two possible states: Red encoded as '1' – and Intermittent Yellow – encoded as '0'. This have been set like this in order to simulate two real world traffic control commands: 'Stop' (Red Light) and 'Pass with caution' (Intermittent Yellow). The initial population of the GA is created randomly.

Every generation a reduced group of individuals, in this study the best two individuals have been selected.

Standard Two Point Crossover operators have been used. At random points – for a pair of parent chromosomes – it selected two random points, cuts them at these positions into three pieces and then interchanges the central chunk. When an individual is chosen to be mutated – according to the mutation probability – the value stored at a randomly chosen position of its chromosome is changed.

In this study a single variable sampled from the traffic simulation has been used as fitness function: the number of vehicles that left the network during the traffic simulation carried out.

6.1.2 Fuzzy sets / logic

Fuzzy logic is widely used in a machine control. Although alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. This makes it easier to mechanize tasks that are already successfully performed by humans.

Fuzzy control systems include input values in terms of logical variables that take on continuous values between 0 and 1 based on fuzzy logic.. In general, many theoretical papers on control of traffic systems using fuzzy statements have been published, [16]described the design of a fuzzy traffic light controller at the intersection of two streets that changes cycle time depending upon the densities of cars behind green and red lights and the current cycle time. A fuzzy model of the system has been built and tested to predict the behavior of the model under different traffic conditions.

Based fuzzy inference system was used to synchronize the time of duration and phase angle of the traffic lights, and also maintain the maximum possible velocity of the vehicles traveling on the road.

A complex adaptive system (CAS) is a network of communicating, intelligent agents where each agent adapts its behavior in order to collaborate with other agents to achieve overall system goals. The overall system often exhibits emergent behavior that cannot be achieved by any proper subset of agents alone. The classifier event action block can implement both crisp and fuzzy rules. This system uses one network of traffic light controller agents at each intersection. Each traffic controller agent uses a fuzzy classifier block to make decisions about traffic light timing in order to minimize local vehicle wait time.

[17] Presented concepts that described a main urgent phase and minor urgent phase. The traffic data are acquired from the detectors in the intersections and lanes. Based on the concepts of main and minor urgent phases, a set of novel fuzzy control rules is developed to control the phases and delay of traffic lights according to the dynamic characters of some correlative traffic intersections.

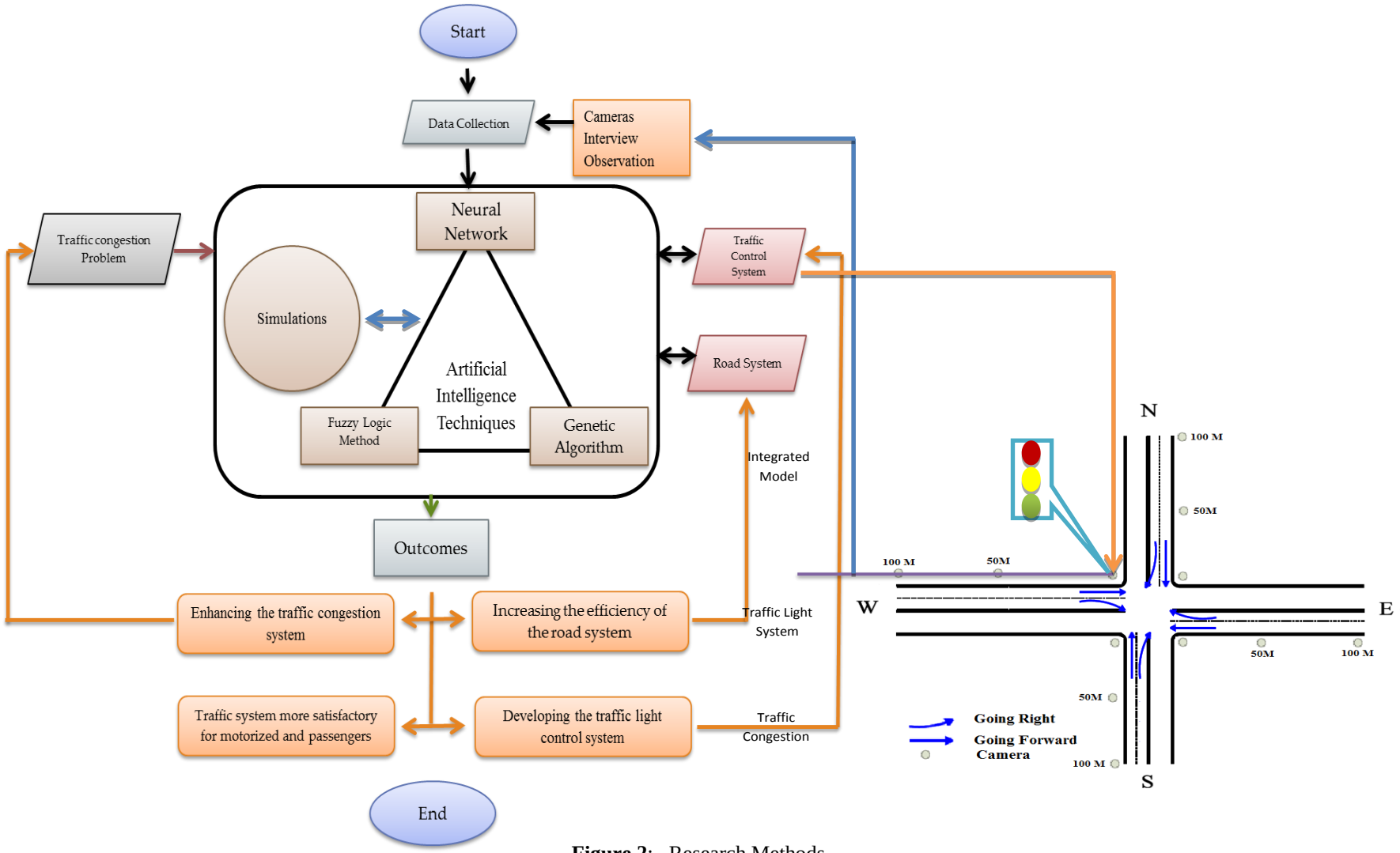

Figure 2: Research Methods

An electro sensitive traffic light, using a smart agent algorithm to reduce traffic congestion and traffic accidents, was proposed by [18]. Specifically, they designed and implemented a system to create optimum traffic signals in congested conditions using smart agent algorithms. This approach antecedently created an optimal traffic cycle of passenger car units at the bottom traffic intersection. Mistakes were possible due to different car lengths, car speeds, and the length of the intersection. Therefore, this approach consequently reduced car waiting times and start-up delay times using fuzzy control of feedback data.

The weakness of all these approaches is the fact that the systems use expert system technology but do not provide any guarantee about the quality of the rules; i.e., an expert system/rule based approach is not ideal for problems that require considerable knowledge. In addition, easily creating and modifying rules can destroy any system. A knowledgeable user can add no value rules or rules that conflict with existing ones.

6.1.3 Neural Network

Traffic light can be controlled by collecting of information about the number of passing vehicles, and processing this data. The neural network computes timing information for the control unit of the traffic lights controller on the basis of the information coming from the cameras or sensors.

The extension neural network consists of extension theory and a neural network that uses a modified extension distance (ED) to measure the similarity between data and a cluster center. ENN is another traffic light control system developed to deal with object recognition in outdoor environments [19]. In outdoor environments, lighting conditions cannot be controlled or predicted, objects can be partially occluded, and their position and orientation is not known a priori. The chosen objects are traffic or road signs, due to ease of sign maintenance and inventory in highways and cities, driver support systems and intelligent autonomous vehicles. A genetic algorithm is used for the detection step, allowing invariance localization to changes in position, scale, rotation, weather conditions, partial occlusion, and the presence of other objects of the same color. A neural network can achieve classification.[20] and [21]have presented an intelligent traffic light control method based on extension theory for crossroads. First, the number of passing vehicles and maximum passing time of one vehicle within the green light time period are measured in the main-line and sub-line of a selected crossroad. Then, the measured data are adopted to construct the extended matter-element model and accordingly the correlation degrees are calculated for recognizing the traffic flow of a standard crossroad. Some experimental results were obtained to verify the effectiveness of the proposed intelligent traffic flow control method. The diagnostic results indicated that the proposed estimated method can discriminate the traffic flow of a standard crossroad rapidly and accurately.

These researchers, however, did not take into account unexpected situations that may cause disruption in the flow of vehicles, where the ENN is used for estimation. Also, the ENN tends to be slower to train than other types of networks (e.g., a single layer neural network) for two reasons. First, a large number of iterations are needed to finish learning all the prototypes. Second, the large amount of data needs large networks. Therefore, the network size should be as small as possible to allow for efficient computations. Sometimes, reducing the size of these data sets leads to ignoring some factors that could improve the estimation process for the flow of vehicles.

6.2 Simulation model

Simulation can reflect the behavior of each individual vehicle in this case we call it microscopic, or it reflects the whole traffic system in this case we call it macroscopic. Simulation in transportation is important because it can study models too complicated for analytical or numerical treatment, can be used for experimental studies, can study detailed relations that might be lost in analytical or numerical treatment and can produce attractive visual demonstrations of present and future scenarios[22].

7. DATA COLLECTION METHOD

Two methods for data collection are planned to be used as follows:

a) Observation: we can count the traffic flow during one day, in some places that suffer from traffic congestion, in order to get an actual data about transportation flow, peak hours, and bottleneck, so we can find out where is the most effected aria by traffic congestion.

b) Ultrasonic, and Image processing Vehicle Detector: Ultrasonic Vehicle detector will be are installed at 300 m intervals used to detect vehicles based on the difference in arrival time of the waves which are reflected from vehicles and roads surface by transmitting ultrasonic wave towards roadways (Figure 3)

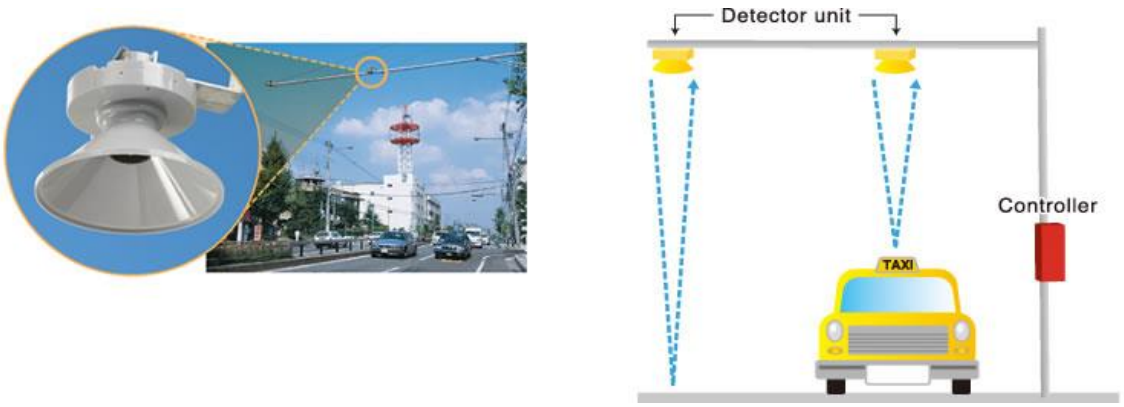

Figure 2 Ultrasonic Vehicle detector

We also plan to use a monitoring camera installed over roads which outputs traffic flow information such as queue length in multiple lanes, volume, classification, occupancy, presence, and speed. The camera will be strategically placed in the cross-sections at the most effected aria by traffic congestion **Figure 4**. The data will be received and processed within the model to adjust traffic lights timing to optimize traffic flow in coordinated traffic lights systems.

Figure 3 Traffic a monitoring camera

Figure 4 Intelligent Traffic Control System

8. EXPECTED RESULTS

The results of the current study are expected to be as follows:

a. Appling a new method, to enhance the traffic congestion system.
b. The method will assist the decision makers to increase efficiency of the road system.
c. Developing the traffic light control system by using artificial inelegance techniques.
d. Reaching to more satisfactory traffic system to both of Motorized and passengers

This research is expected to be very important and beneficial for Malaysia.

9. SUMMARY

In this study, we plan to apply a new Artificial Intelligence Techniques and simulation model In order to elicit a general diagnosis for the traffic congestion problem in Kuala Lumpur and Kuantan, we will apply an integrated model using, Neural Network (NN), Fuzzy Logic (FL) , Genetic Algorithm (GA), and Simulations (SMs).

The results of this study will be reported and used to suggest and apply more efficient transportation policies with the aim of providing useful insights on traffic congestion problem, and to assist Malaysian decision makers to elaborate the best transportation policies.

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