Study and Design of Fuzzy Logic and Its Application in Traffic Control

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Abstract

The growth in the number of automobiles on the road, combined with a shortage of available road space, has resulted in traffic congestion in many areas. Congestion has a negative impact on production, diminishes efficiency, and resulting in loss of energy. As a result of the traffic signal system in place at intersections, this bottleneck is worsened to a significant degree. Because a standard traffic system does not take into account the fluctuation in traffic signal time lengths, it is impossible to maximize its efficiency. The useof our proposed fuzzy traffic signal management system may be able to decrease traffic congestion. Instead of a predetermined amount of time, it takes into consideration the current density of traffic at the intersection while deciding the duration of the green light period. As a result of our optimization of the duration of the green light time, our system is better equipped to handle congestion than other systems. In recent years, many studies have been undertaken on fuzzy traffic control systems, even though there are many more intricate systems available in the literatures.
Keywords: Fuzzy Logic, Traffic Management, Traffic Light Control System, Intersection.

I. INTRODUCTION

Fuzzy logic, for example, might be used to traffic management to get a desired outcome. Designing a technique to cope with traffic congestion with the use of modelling lanes was done with the use of land-blocking. This approach teaches someone how to block lanes for1, 2, and 3 lane scenarios with the help of modelling lanes. AIMSUN software packages for small-space applications It establishes a route that is simple to follow. Traffic lanes act as visual cues for drivers. Obtaining an estimate of how long it takes on average to check and authenticate an item. According to the results of the testing, the ambiguous reasoning was effective in appropriately assessing traffic conditions. In order to discover the most direct way through traffic, researchers have used similar approaches in the past, and they have started to use them to ease traffic congestion.

TSC (Traffic Signal Control) is the industry leader in artificial intelligence when it comes to reducing traffic congestion while also increasing road safety, enhancing travel efficiency, and reducing environmental impact (CI: Computational Intelligence). On motorways and other public highways, there has been considerable interest in the use of artificial neural networks, fuzzy logic, and evolutionary computing approaches to help ease traffic congestion and the introduction of additional traffic. For example, an Algerian researcher has developed a mechanism for predicting road accidents in order to increase road safety while also reducing traffic congestion. It is possible to detect hazard factors associated with the appearance of a road in traffic management systems by using the MATLAB software, which is based on fuzzy logic.

II. RESEARCH METHODOLOGY

According to the studies cited above, fuzzy logic controllers perform better than pre-timedand actuated controllers when it comes to overall system performance. However, the majority of studies focused on implementing control measures where control decision was taken considering the queue length and arrival rates at green and red light lanes individually, and not directly comparing them. Mohammad Hossein Fazel Zarandi and Shabnam Rezapour in their model have used ratio of queue lengths at the green and red lanes and the ratio of arrival rates at those lanes to make the control decision. Here, we propose a fuzzy logic controller for traffic signal where decisions are made by comparing the traffic conditions of all the lanes of the intersection and we use the difference of queuelengths at the green and red-light lanes and the difference of arrival rates at those lanes todo the comparison. In the present model, we consider intersections where only straight and left turns are allowed.

At a signalised intersection, the red, green, and amber (or yellow) phases of a traffic light cycle are normally activated one after the other over a set length of time. Those cars travelling straight ahead of the signal, turning left or continuing straight ahead are the only ones permitted to cross the intersection while there is an active green light. If there is an operable red light in place at the intersection, traffic cannot pass through. Because of this, cars are authorised to make right turns while the red light is illuminated, provided they do not obstruct traffic that has the right-of-way in the process. The transition from the green to the red phase initiates the activation of the amber phase. A specified amount of time is allotted to the amber phase, for the most part. Traffic conditions have an impacton the duration of both the red and green phases throughout a large geographic area.

PROBLEM STATEMENT

Congestion was caused by an increase in the number of cars and a lack of suitable highwaysin many cities. Congestion reduces production, reduces efficiency, and causes wasteful use of energy. The traffic light system, which manages the traffic lights at junctions, is a significant contributor to the congestion. It is difficult to maximise the efficiency of a normal traffic system since it does not take into account the variation in traffic signal time durations. In order to alleviate traffic congestion, we recommend using a fuzzy traffic lightcontrol system like the one we've developed. It takes into account the present traffic density at the junction when determining the length of the green light time period. Our system is better able to manage congestion than other systems since we have optimised thegreen light period length.

The intersection shown in Figure 1 (a) is what we're working with here. North, South, East,and

West are denoted by these letters (N, S, E, W). As seen in Figure 1 (b), our traffic management system is presented.

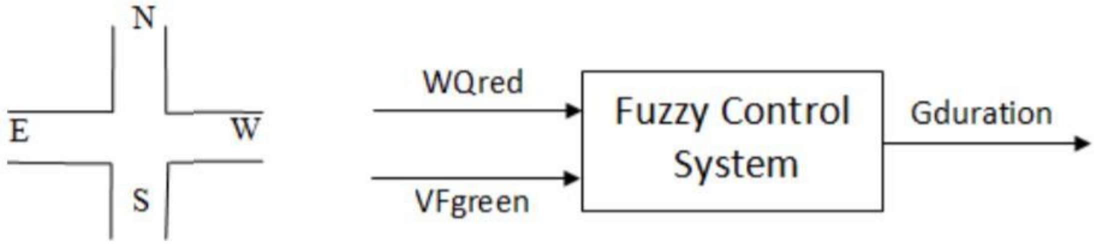

Figure 1: (a) Intersection and (b) Controller

To constructing Gduration, we utilise two inputs: WQred and VFgreen. The time during which the system applies fuzzy rules to its two inputs and generates the output is referred to as the Gduration. In the case of WQred, the number of cars waiting at a red light, as calculated by a detector positioned in the intersection, is one of the inputs into the control system for the vehicle count detector. The membership functions for fuzzy sets in WQredare divided into three categories: Low (L) = 0 to 6.4, Medium (M) = 4 to 12 and High (H) =9 to 16 or more.

This figure represents the number of automobiles that pass by a given point in five secondsas a second input. Each lane of the intersection is equipped with a detector that keeps trackof the traffic that passes through it. Membership functions are classified as follows: low (L),medium (M), and high (H) (H).

III. DATA ANALYSIS

A Methodology for the Design of Fuzzy Logic Traffic Controllers Field Programmable Gate Arrays (FPGAs) are used in the following applications:

It has been argued how to implement a traffic management system at a four-way intersection. Turns are authorized in any direction, including forward, right, and left, on any given approach (northbound, eastbound, southbound, and westbound). They propose that the duration of the green phase interval be adjusted to maintain a more balanced flowof traffic on the highway. Motorists approaching a junction with a significant amount of traffic are permitted the right of way to cross the intersection for a longer length of time. The purpose is to minimize the number of autos queuing up at the four-way junction by dynamically raising or lowering the duration

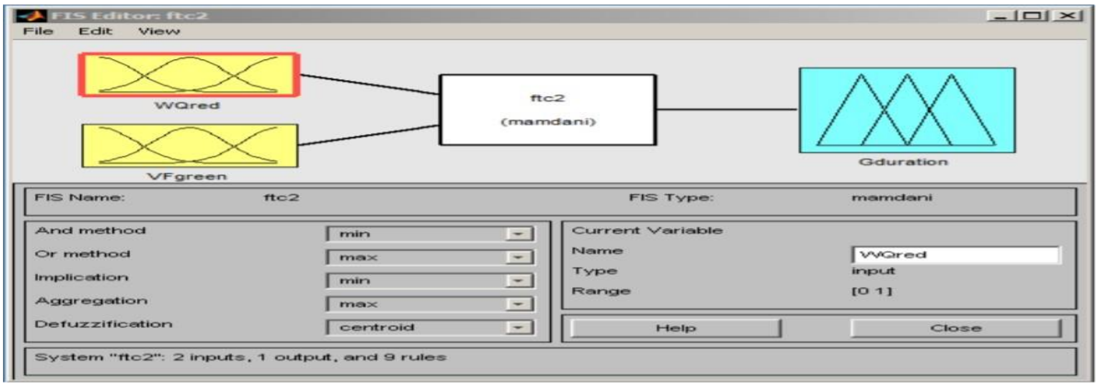

Figure 2: FIS editor

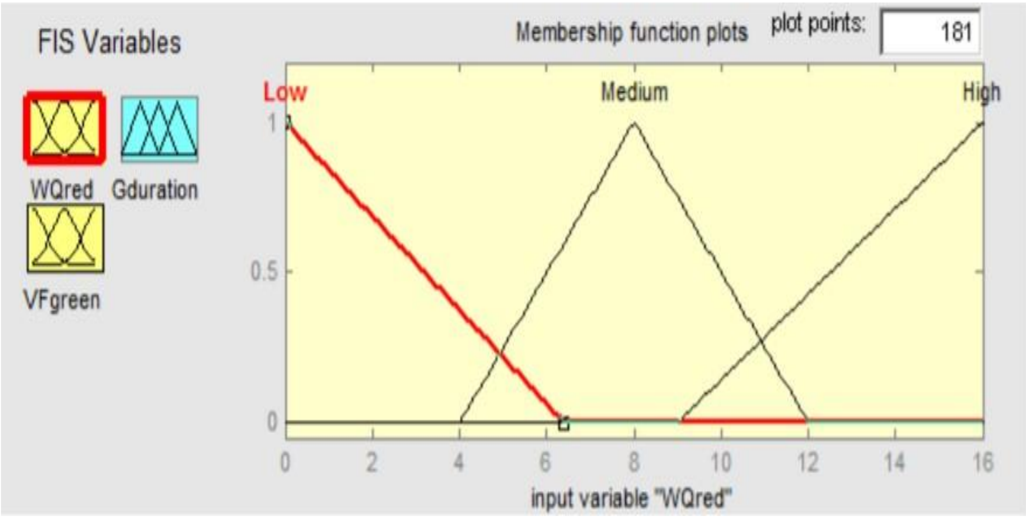

Figure 3: Membership function (WQred)WQred: low=0 to 6.4, Medium= 4 to 12, High= 9 to 16

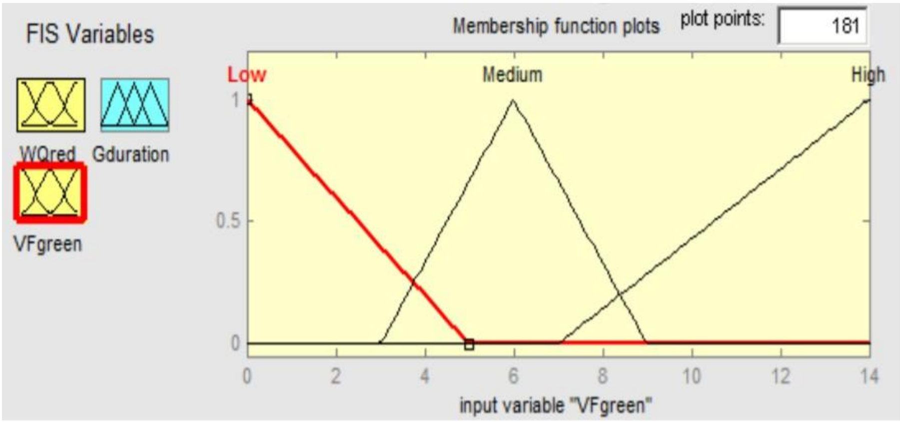

Figure 4: Membership function (VFgreen) VFgreen: low=0 to 5, Medium= 3 to 9, High= 7 to 14

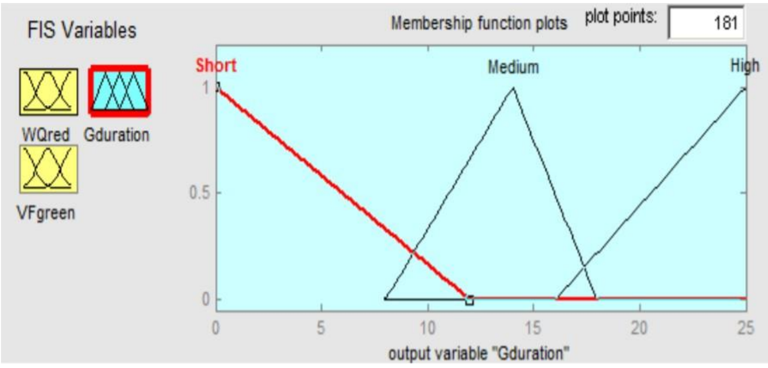

Figure 5: Membership function (Gduration)Gduration: Short=0 to 12, Medium= 8 to 18, High= 16 to 25

Using the rule editor shown in Figure 4 of the FIS, it is simple to derive the rules defined in the previous section, which can then be visualised graphically using the rule viewer shown in Figure 5, where the aggregate output is shown at the bottom and the centre of the area is considered for defuzzification, as indicated by the red colour.

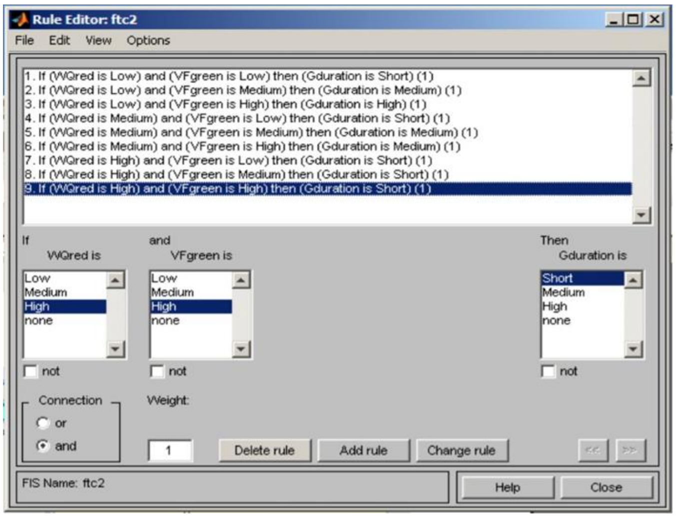

Figure 6: Rule editor

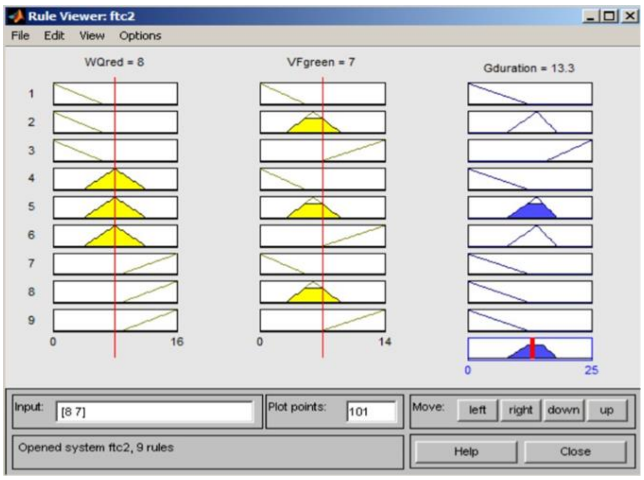

Figure 7: Rule Viewer

FIS output surface:

Figure 6 illustrates the system's surface view, which depicts the data distribution between input and output. A three-dimensional output surface may be generated by the Surface Viewer if two of the inputs differ.

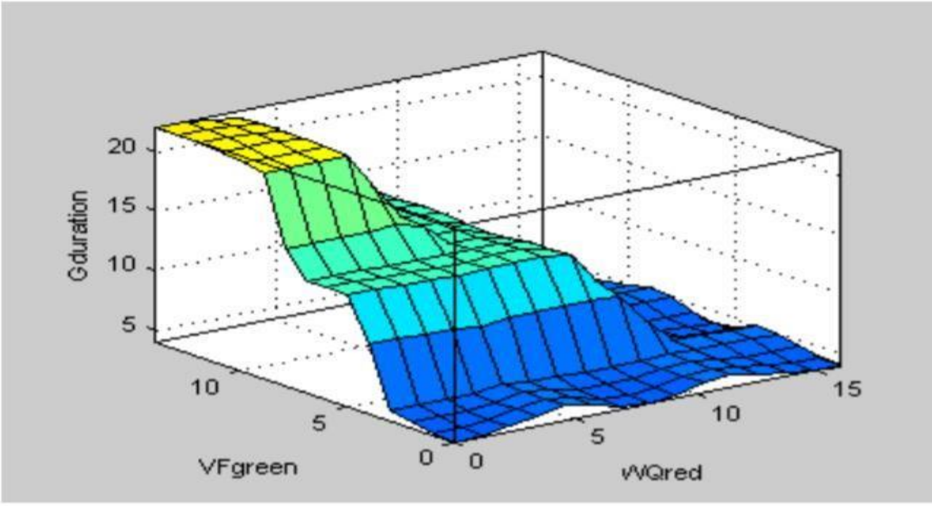

Figure 8: Surface viewer System Description for Fuzzy Controls

Traffic flow data, such as the number of cars and their arrival rates in both green and red light lanes as well as the current time spent waiting in red light lanes, will be inputs into the fuzzy control system we propose. There is a significant disparity in traffic volume between green and red lanes, as well as in arrival rates between the two lanes. As a result,we also take into consideration the presence or absence of emergency vehicles (EV).

To implement this model, the controller chooses whether or not to alter the current light directions, i.e. whether or not the lanes now under green light should remain such, after every t seconds. We decide that regardless of other traffic circumstances, the light directions should change instantly if the current waiting time (i.e. the time since the previous green light has gone off) of the red light lanes surpasses a particular predeterminedvalue (say, Tmax). To that end, we both agree that an emergency vehicle should instantly turn the equivalent green light. If an EV is present in both the green and red light lanes, the EV on the green light lane should be permitted to pass first, and the signal should change quickly after. The duration t may range from one second to ten seconds dependingon the speed of the controller.

For the proposed signal control system, the following is a step-by-step procedure:

Step 1: The sensors at the junction provide the system with the information it needs.

Step 2: Checks to see whether there is an EV present. If an EV is present, then go to Step 1 and adjust the signal appropriately. Otherwise, go to Step 3..

Step 3: Whether the current waiting time at a red light is more than Tmax, this function checks to see if it is. Step 1: If the value is more than Tmax, the current green signal shouldbe changed, and the process should be repeated. If it isn't, go to the next step..

Step 4: Calculate the priority of the red light lanes to determine whether the present green signal should be changed or not, then carry out the choice and return to Step 1..

We're not going to go into the nitty-gritty of how to do Steps 1-3. Here, we discuss Step 4 assuming that EV and Tmax are taken care of..

Fuzzification:

The control parameters or input variables are:

NG = Number of vehicles in the green light lanes,NR = Number of vehicles in the red-light lanes, DN = N_R - N_G,

AG = Arrival rate at the green light lanes (no. of vehicles arriving per sec.),AR = Arrival rate at the red-light lanes (no. of vehicles arriving per sec.), DA = AR - AG,

WT = Waiting time at the red-light lanes,EV = Emergency vehicle.

All these inputs (except EV) are crisp variables which are now fuzzified. The fuzzy sets corresponding to DN, DA, WT and EV are as follows:

Table 1: Fuzzy sets corresponding to inputs

DN	DA	WT	EV
Negative Big(NB) Negative Medium(NM) Negative Small(NS)	Negative Big (NB) Negative Medium(NM) Negative Small(NS)	Small (S) Medium (M) Long (L)	Present(P) Not Present (NP)
Zero(ZO) Positive Small (PS) Positive Medium(PM) Positive Big(PB)	Zero(ZO) Positive Small (PS) Positive Medium (PM) Positive Big(PB)		

DN is NB/ NM/ NS means that the number of vehicles in the green light lanes is more than that of the red-light lanes. Whereas DN is PS/ PM/ PB means the reverse. Similar is the case for DA.

The corresponding output variable is the priority of red-light lanes. The fuzzy sets corresponding to output are Very Low (0), Low(0.25), Medium(0.5), High(0.75) and Very High(1.0). Each output's weight is represented by the number in the bracket.

Membership functions for the fuzzy sets stated above are used to fuzz up the input values.

These membership functions are shown in the graph below.:

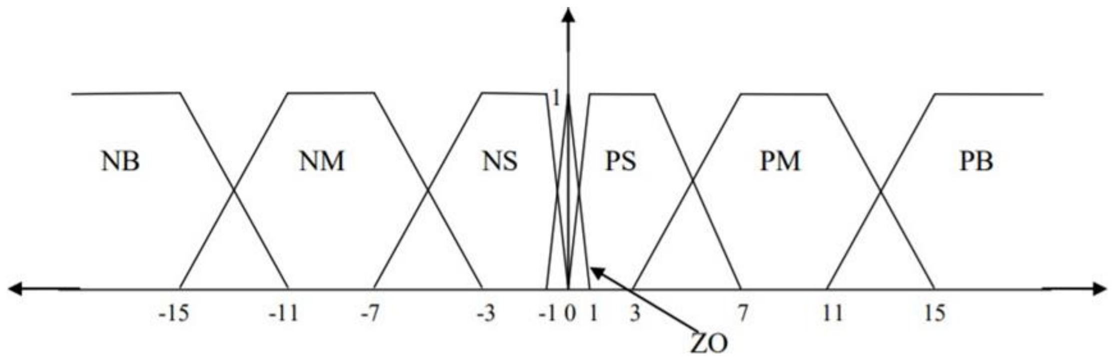

Figure 9: Fuzzy sets for DN

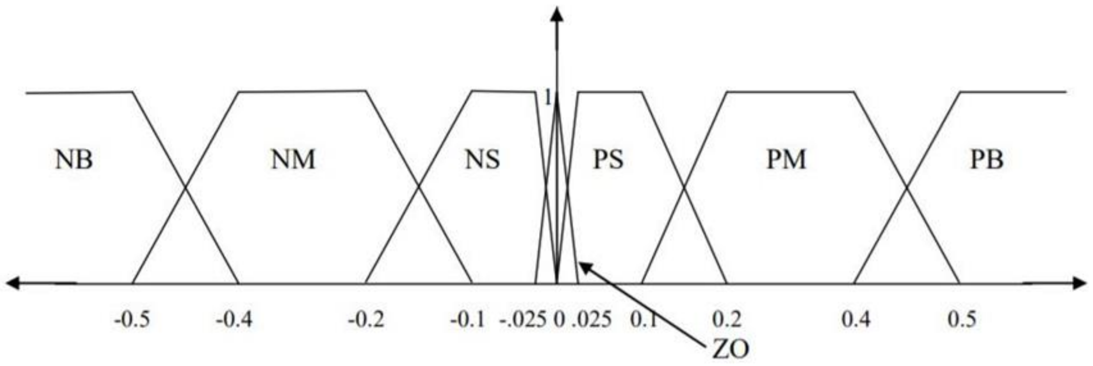

Figure 10: Fuzzy sets for DA

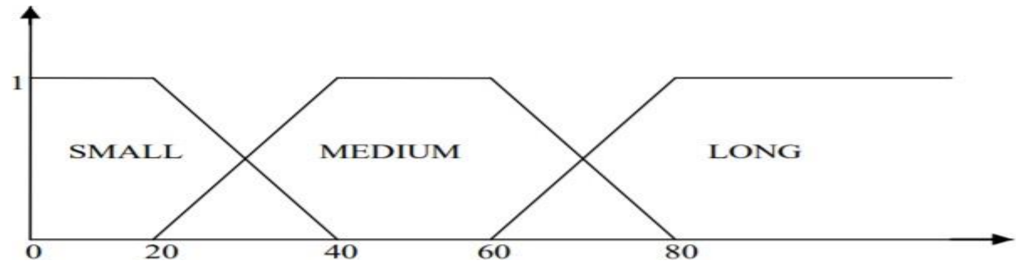

Figure 11: Fuzzy sets for WT

These membership functions may vary for varying traffic conditions in different places. Expert opinion will be taken to construct these functions for a particular intersection.

IV. CONCLUSION

The problem of traffic congestion at intersections has become on of the most severe problems in cities. Not only does it waste time and money but has become an environmental problem due to emissions of running engines without the motion of vehicles. The flow of traffic changes with the time of day, day of the week and the month of the year. Traditional traffic light control systems use timing switches or micro controllers to control the lights. The timing of the traffic lights is calculated and embedded in to the controllers. The most advance of these systems have controllers, which vary the timing ofthe lights according to the time of day. These systems have a drawback of their own. Theycannot adjust to sudden variations in the flow of traffic or according to the day of the weekor month of the year. The main purpose of the development of a fuzzy logic-controlled traffic lights system is to minimize the congestion at an intersection. Fuzzy logic enables usto embed human intuition into computer systems. This would be similar to having traffic at an intersection being controlled by a human.

This implies that the system requires sensors to detect changes in the environment and a rule base to determine the appropriate response. Traffic congestion on a particular approachoccurs when the number of vehicles entering the intersection cannot exit it due to the congestion on the exiting routs. A human controller would open a particular approach fora longer duration if the number of incoming vehicles were high. If there were congestion on a particular approach a human would reduce the amount of time he leaves the approachopen. This means the open time of a particular approach increases with the number of incoming vehicles and decreases with the increment of congestion (density).

FUTURE SCOPE

Fuzzy traffic controllers may be extended in the future to include pedestrian control logic.The city's traffic controllers may interact with each other by establishing a network connection and providing information about the current traffic status at their junctions to the fuzzy controller. The controller will create output based on these inputs to better regulate congestion in light of the present traffic circumstances at the intersections of the network of neighbors traffic controllers.

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