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S. Mohanaselvi and B. Shanpriya

Application of Fuzzy Logic to Control Traffic Signals

S.Mohanaselvi[1,a)] and B.Shanpriya[2, b)]
[1,2]*Department of Mathematics, Faculty of Engineering & Technology, SRM institute of science & Technology, Kattankulathur – 603 203, Chennai.Tamilnadu, India*
Corresponding author: [a)]mohanaselvi.s@ktr.srmuniv.ac.in;
[b)]shan121096priya@gmail.com

Abstract. In this paper, using fuzzy logic technique an intelligent traffic signal control is introduced. The existing traffic light controllers would not give a best solution to this problem as it changes traffic lights based on constant cycle time. Fuzzy logic controllers can be used to deal with linguistic and unpredictable traffic data to control the signal timings. This paper aims at developing an intelligent traffic light controller using fuzzy logic technique and illustrated a control procedure using if – then rules.
Keywords: Fuzzy logic, Traffic control, Triangular membership function, Fuzzy rule base system.

INTRODUCTION

Traffic congestion is one of the critical problems to be resolved to improve the economy of any country. The proper way of controlling traffic congestion is done by using traffic signals. Due to increase of vehicles in roads, public behavior and fixed time controlled traffic signal systems have not provided a solution to high traffic congestion. The aim of the traffic congestion problem is to minimize the delays in roads by effectively using the existing traffic signal systems without constructing new roads. Traffic system is more dependent on parameters such as time, day, season, weather and unpredictable situations. The difficulty and uncertainties present in the existing traffic system can be rectified by using an intelligent traffic control system which continuously sense and adjust the timings of traffic lights depending on the traffic jam. If these parameters are not taken into consideration, the traffic control system will create delays. The difficulty and uncertainty of traffic clogging made an ultimate representation of such research. Traffic congestion patterns expand over time period as an effect of communications between target and congestion over space. At its most basic congestion is caused when the level of traffic exceeds road capacity. L.A Zadeh proposed a fuzzy set theory to deal with uncertainties present in real world situations. The fuzzy logic controlled traffic light utilizes sensors that tally cars and permits an improved estimation of modifying traffic patterns .To proposed the average weight of vehicles at a intersection lane an adaptive controlled design strategy was proposed by Asthuosh Choudhary [1]. A comparison between different fuzzy logic control algorithms was made by I N Askerzade [2]. Babangida Zachariah [3] introduced a fuzzy logic inference system to optimize state phase scheduling of traffic light system (SPSTLS). Using states machine B Dilip [4] proposed an efficient design. Using sugeno method Erwan Eko Prasetiy [5] proposed an adaptive traffic light controller. A traffic signal control method for a 6-phase intersection was proposed by Fuyang chan [6]. Ms .Girija H Kulkarni [7] using VB6 environment in MATLAB proposed a fuzzy traffic controller for an isolated intersection. This simulation result verify the performance of our proposed integrated traffic light control system using RFID technology and fuzzy logic was projected by Javed Alam [8]. Jarko niittymaki [9] make suggestion fuzzy control principles are very competitive isolated multi-phase movements. Kamlesh Kumar Pandey [10] proposed a fuzzy decision support system and component of fuzzy controller with fuzzy rule base. Navneett Kaushal [11] proposed two algorithms of fuzzy rule base system for an isolated traffic intersection in VB6 environment. O. M Olanrewaju [12] had proved that the pedestrian delay has significant contribution to traffic control to enhance the safety of the pedestrian. Constructed the effectiveness and actual situation of the traffic control process are investigated by Sandeep Mehan [13]. In this paper controlling traffic flow for an isolated four lane traffic junction using fuzzy logic technique are discussed. This paper has been organized as follows. In the following section II a outline about fuzzy traffic signal controller is described briefly . Then assumptions and constraints of isolated four lane traffic controller is introduced in section III are explained. Then in the next section IV and V about fuzzy inputs, output, linguistic variables and

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their membership functions. Then different fuzzy rule bases have been set for traffic signal processing and a simulation of fuzzy rules using mat lab is implemented and the results are presented

FUZZY TRAFFIC SIGNAL CONTROLLER

Now a days predetermined traffic lights are used under time of the day scheme to control traffic congestion. But it does not offer an optimum solution for the fluctuations of the traffic condition. A fuzzy logic control system provides a better optimal solution for the fluctuating traffic system. Controlling the traffic flow system using fuzzy technology has the ability to convert human thinking process into an algorithm using some mathematical models. Implementation of real rules which are similar to the way that traffic policemen would think to manage traffic signal lights can be done by fuzzy if-then rules. The traffic signal controllers are supposed to adjust the cycle time of green light signal depending upon the amount of vehicles arrival which would maximize the traffic flow and control the regular waiting time. The inputs of fuzzy signal control system are generated by the help of an experience. Fuzzy rule based system derives actions from given inputs by constructing if-then rules which represent the relation among the linguistic variables. In general, a fuzzy traffic signal controller will improve the traffic protection in the junction, usage of junction at its maximum level and minimize the delays. In a traffic light system red light indicates the arriving vehicles to be stopped, green light indicates the arriving vehicles to be allowed and the yellow light indicates the switch over of red light or green light.

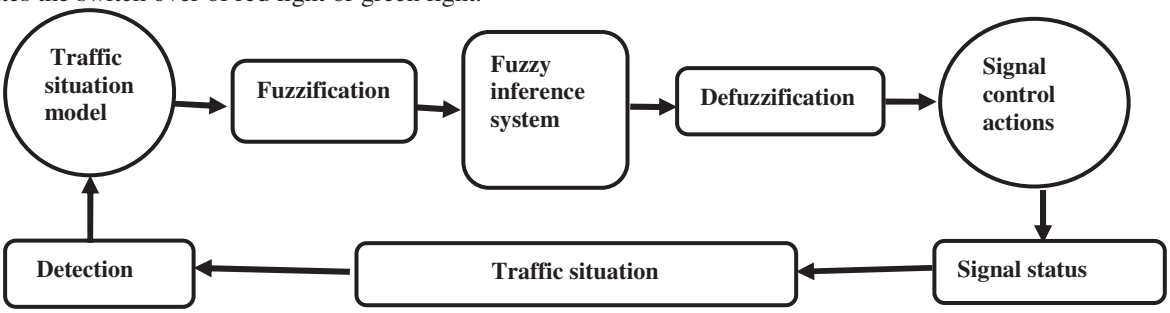


Figure 1: Fuzzy Traffic Signal Controller

An layout of isolated four lane traffic junction is given

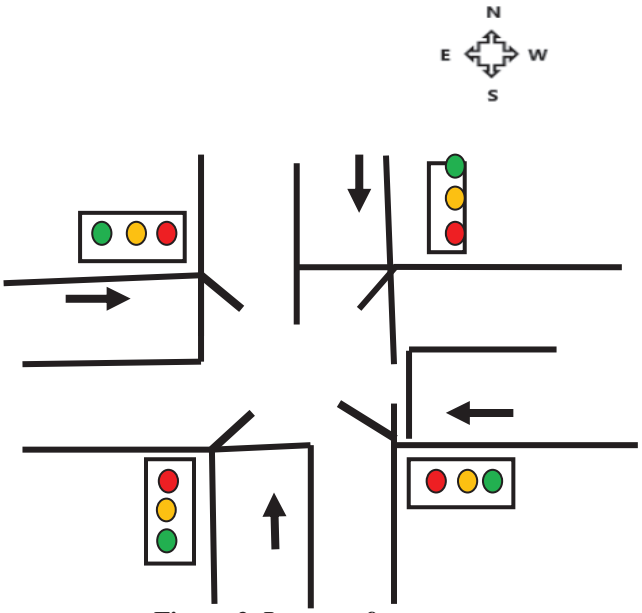


Figure 2: Layout of isolated four lane traffic junction

ASSUMPTIONS AND CONSTRAINTS

The following criterions are made to design the proposed fuzzy traffic signal control system:

- The traffic is allowed from north south west and east direction in an isolated four lane traffic junction.
- Initially the traffic from the north direction will be allowed to move and then the traffic from the east, south and west direction will be allowed to movie in progress.
- When the traffic from north and south are allowed to move then the traffic from east and west are terminated and also vice versa.
- No left and right turns are considered.
- The main duty of the fuzzy logic controller is to observe the traffic from north and south direction on one side and also the direction from east and west on another side.
- The main lane is assumed as north south direction.
- Maximum and Minimum time of green light signal is 60 seconds and 2 seconds respectively.

FUZZY INPUTS, OUTPUT AND THEIR LINGUISTIC VARIABLES

In the proposed fuzzy logic signal controller three fuzzy input variables are chosen namely

1. Number of vehicles arriving at the junction or the number of vehicles passing during green light(AV-Arrival Vehicle)
2. Number of vehicles waiting on the queue on the junction or the number of vehicles waiting during the red light (QV-Queuing Vehicle)
3. Weather variation (F-Humidity or Fog).

The green light duration (GD) is the output variable which will provide the extension time required for green light on the arrival side.

The following table 1 provides the range of values for fixing the input and output variables

TABLE 1

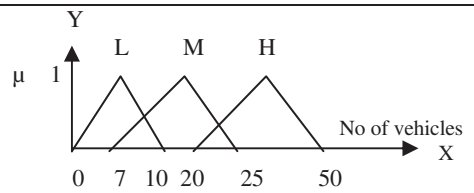
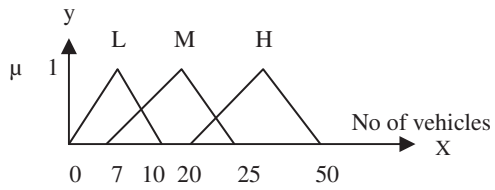
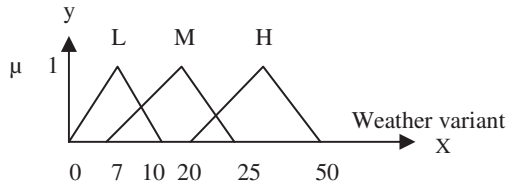
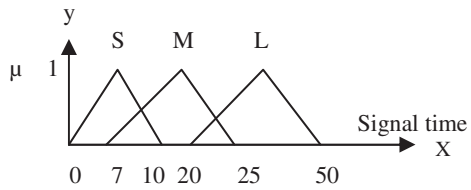
Arriving vehicle		**Queuing vehicle**		**Fog**		**Green light duration**	
Range	Linguistic variables	Range	Linguistic variables	Visual range (in meters)	Linguistic variables	Time (in sec)	Linguistic variables
00 – 10	Less	00 - 10	Less	1000 – 1500	Low	00 - 10	Short
07 - 25	Medium	07 - 25	Medium	400 - 1200	Medium	08 - 30	Medium
20 - 50	High	20 - 50	High	50 - 500	High	25 - 60	Long

FUZZY INPUTS, OUTPUT AND THEIR MEMBERSHIP FUNCTIONS

Triangular fuzzy numbers are often used in many applications due to its computational efficiency. The graphical representation of the membership functions of the input and output variables are given below. The amounts of the traffic on the arriving, queuing side have (Less, Medium, High) numbers of vehicles and also the weather variant fog have (Less, Medium, High) and the Green time duration have (Short, Medium and Long).

The following table 2 provides the membership function of each input and output variables,

TABLE 2

		MEMBERSHIP FUNCTIONS	DIAGRAM
INPUTS	Arriving vehicle	Less Medium High	
	Queuing vehicle	Less Medium High	
	Fog	Less Medium High	
OUTPUT	Gduration	Short Medium Long	

For the input fuzzy variables for arriving vehicle and queuing vehicle the universe of discourse (x-axis) is number of vehicles, fog the universe of discourse is the visibility range in meters and y-axis for all input variables membership degree varies from 0 to 1. Output fuzzy variable's universe of discourse is the length of time in signal to be extended in seconds.

FUZZY IF-THEN RULES

For executing any activities human beings frame rules for implementing it. This human intelligent process is similar to the fuzzy inference mechanism. On the basis of 3 input variables nearly 27 fuzzy rules are framed to obtain the following output and given in table 3.

TABLE 3

Rules	Inputs			Output
No	Arrivingvehicle	Queuingvehicle	Fog	G duration
1	H	L	L	S
2	H	L	M	M
3	H	L	H	H
4	H	M	L	M
5	H	M	M	M
6	H	M	H	H
7	H	H	L	H
8	H	H	M	H
9	H	H	H	H
10	M	L	L	S
11	M	L	M	M
12	M	L	H	M
13	M	M	L	M
14	M	M	M	M
15	M	M	H	M
16	M	H	L	H
17	M	H	M	H
18	M	H	H	M
19	L	L	L	S
20	L	L	M	M
21	L	L	H	M
22	L	M	L	M
23	L	M	M	H
24	L	M	H	M
25	L	H	L	S
26	L	H	M	M
27	L	H	H	H

In this paper fuzzy logic tool box in Mat lab is used to implement the proposed fuzzy logic control system for an isolated four lane traffic junction and fuzzy rule set. Using the graphical user interface (GUI) the membership function of input and output variables (Fig 3) are designed as follows

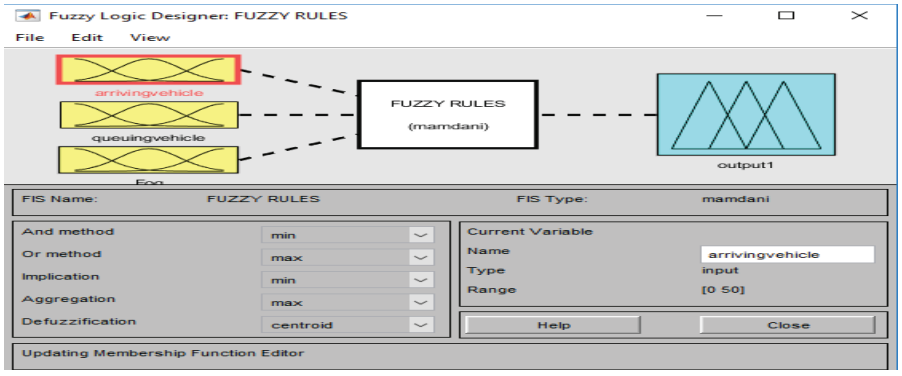


FIGURE: 3 FIS editor

The figure 4 shows the membership function for the input variable arriving vehicle (AV). The membership function for the arriving vehicle are less = 0 to 10, medium = 7 to 25 and high = 20 to 50

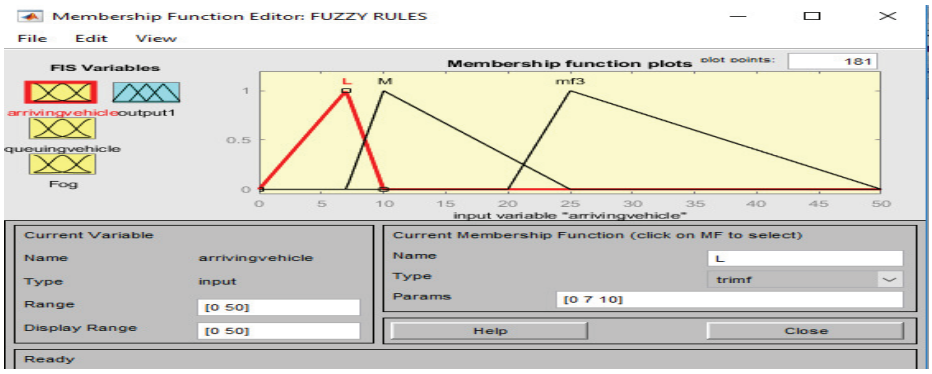


FIGURE 4 : Membership function (Arriving vehicle)

The figure 5 shows the membership function for the input variable queuing vehicle (QV). The membership function for the queuing vehicle are less = 0 to 10, medium = 7 to 25 and high = 20 to 50.

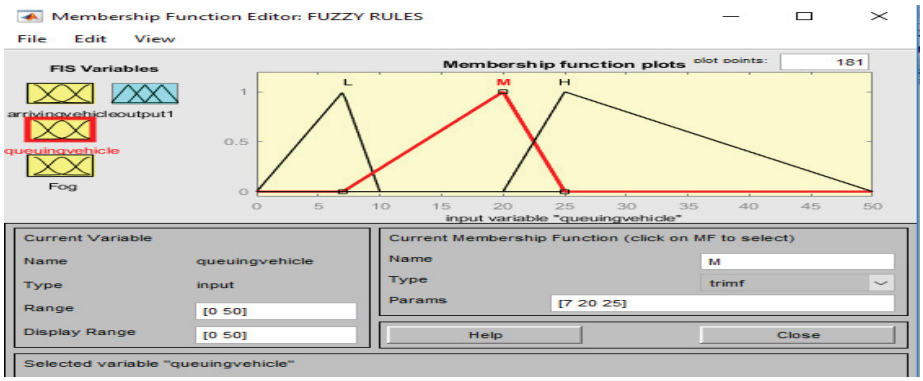


FIGURE 5 : Membership function (Queuing vehicle)

The figure 6 shows the membership function for the input variable fog (F). The membership function for the fog (in meters) are low = 1000 to 1500, medium = 400 to 1200 and high = 50 to 500.

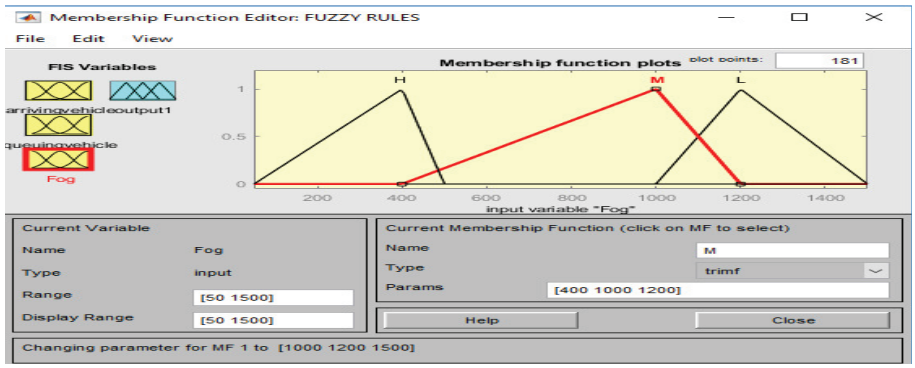


FIGURE 6: Membership function (Fog)

The figure 7 shows the membership function for the output variable green light duration (GD). The membership function for the green light duration (in seconds) are short = 0 to 10, medium = 08 to 30 and high = 25 to 60.

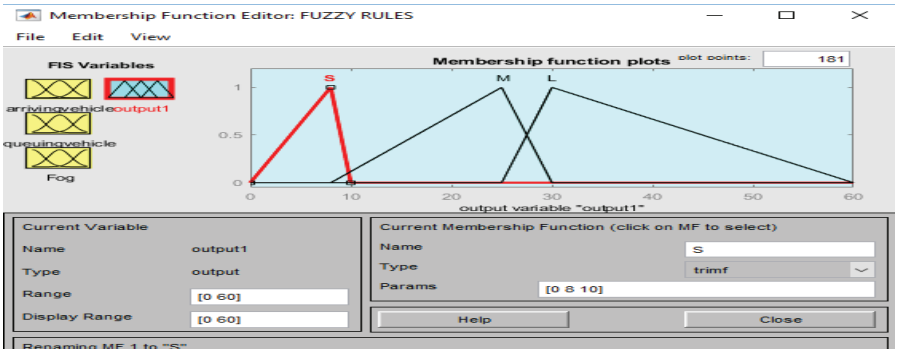


FIGURE 7: Membership function (Gduration)

Using FIS editor in MATLAB the proposed fuzzy if-then rules are inserted.

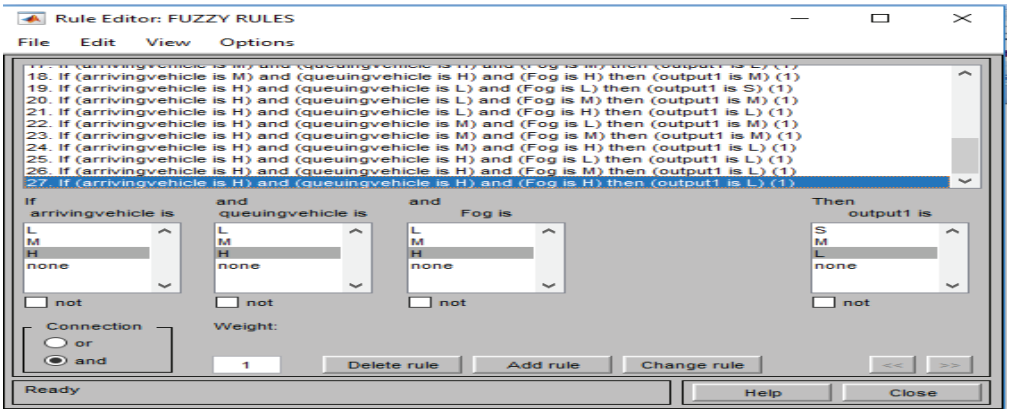


FIGURE 8: Rule Editor

FIS can view graphically using rule viewer and surface viewer.

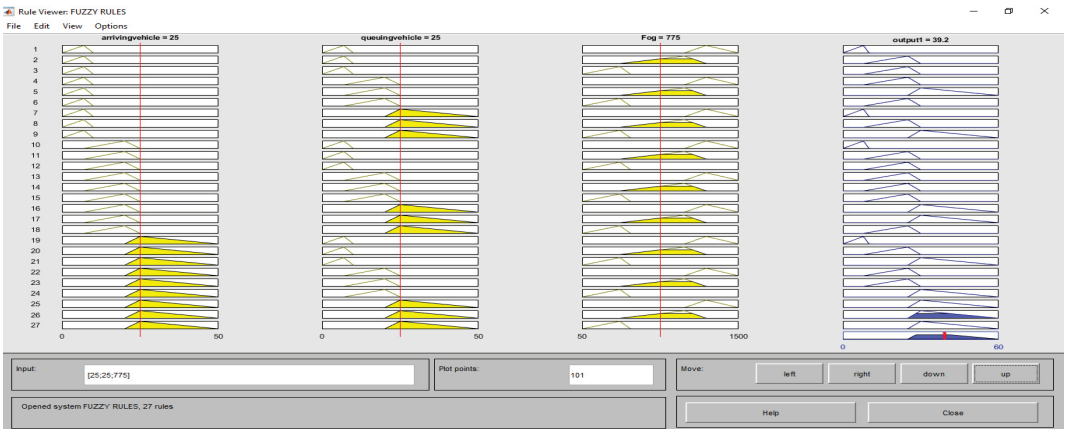


FIGURE 9: Rule viewer

Figure 10 shows the surface viewer of the proposed control system. The surface viewer is a 3-Dimensional output surface, here drawn for arriving vehicle and queuing vehicle. For varying output we can generate different surface viewer.

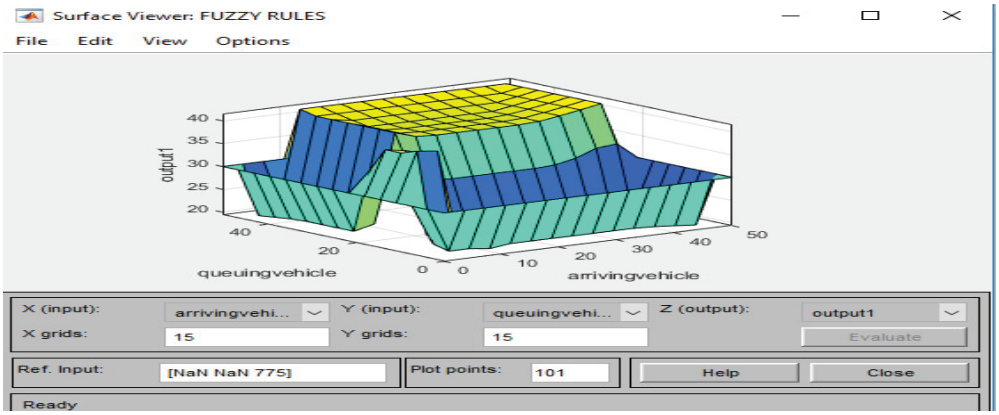


FIGURE 10: Surface viewer

To provide suitability performance, this paper aims at proposing a fuzzy logic control system to control the traffic congestion at a junction. By considering the fuzzy inputs AV, QV and F, the fuzzy rules have been framed by using fuzzy logic tool box in mat lab, the traffic congestion at a junction have been estimated. It is observed that by using fuzzy logic techniques, a better estimation of the traffic congestion at an intersection during traffic flow is obtained.

CONCLUSION

In this paper an effort has been made to develop a fuzzy logic controller to improve the performance of the traffic signal controller. The number of arriving vehicles, queuing vehicles during different weather conditions have been taken into account for estimating the green light extension time is made by using the proposed fuzzy logic controller.

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