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A Rule based Fuzzy controlled Decision Support System for Intelligent Traffic Control System

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Abstract - Congestion of roads particularly at different junction points due to vehicular traffic has become a chronic problem all around. Right now in India, a static timer is used to control the timing of the traffic light which results in a lot of problems. This paper introduces a fuzzy logic (FL) based decision support system (DSS) for intelligent traffic control system. The primary focus of the paper is on the algorithm used to reduce the time spent extra on the traffic light junction so as to save the fuel, time and to reduce the possibility of accidents occurring at the traffic light junction. The proposed system uses three input parameters; namely maximum length of vehicles behind traffic light, left green time, and no. of vehicles reaching the traffic light in a short period of time and one output, extension time which is used to control the congestion at the traffic light junction. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine is used to deduce from the input parameters.

Keywords - Fuzzy Logic, Fuzzy Inference Systems (FIS), Decision support system, Traffic control system

I. INTRODUCTION

In most of the cities in India, congestion of roads particularly at different junction points due to vehicular traffic has become a chronic problem which adds up to cost of travel due to reduction in productivity, late delivery of goods and in case of emergency the slow moving traffic is fatal. Further number of vehicles over to Indian roads, and across the world too, has grown tremendously due to lower interest rate for vehicle and increase in disposable income of middle-class. Due to randomness in the traffic density, the current traffic control system in the cities is inefficient. In a recent study of Delhi, it was reported that 10% of road fatalities on Delhi roads occur due to jumping of red lights by motorists. Last year, as many as 6,420 motorists were prosecuted for jumping red lights at one intersection in Delhi. Apart from this, delay in traffic flow causes fuel loss also. Everyday due to idling of vehicles, Delhi is loosing 0.37 million kilograms of CNG, 0.13 million litres of diesel and 0.41 million litres of petrol. Engine exhaust, by petrol, diesel and gas, contains more than 40 hazardous air pollutants. Around 70% of the air pollution comes directly from the emissions from vehicles. Slow speeds and idling vehicles produce, per trip, 4 to 8 times more.

At present, signals are controlled through a preset timing system. It results in pileups during peak hours and also induces drivers to skip signals during lean hours. If the timer of traffic signal can be programmed according to the continuously varying traffic density, the problem of traffic congestion can be reduced to a significantly lower levels [6]-[7].

In this work, a fuzzy logic (FL) based decision support system (DSS) for intelligent traffic control system is proposed. It focuses on the algorithm used to reduce the time spent extra on the traffic light junction so as to save the fuel, time and to reduce the possibility of accidents occurring at the traffic light junction. The proposed system uses three input parameters and one output parameter. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine is used to deduce from the input parameters.

Rest of the paper is organized as follows. Section 2 gives the related work done by earlier researchers in the said field of decision support system for intelligent traffic control system. Section 3 gives the general Structure of fuzzy logic based decision support system. Design of the proposed system is given in section 4. Finally work is concluded in section 5.

II. RELATED WORK

In [1] authors proposed few equations for the optimal cycle length and the green phase time assignment. These forms the basis of fixed-time control. Authors in [2] and [3] modified the theory given in [1] so as a better signal timing algorithm

can be given by the name ARRB. The proposed approach however cannot respond to real-time variations. Few adaptive traffic control systems have been proposed for traffic control like SCOOT [4], SCATS [5]. Signal control using fuzzy logic controllers using AI has been proposed in [8] and using genetic algorithm in [9].

III. GENERAL STRUCTURE OF FUZZY LOGIC BASED DECISION SUPPORT SYSTEM

The general structure of fuzzy logic based decision support system is shown in figure 1. During fuzzificationn sub-process all three crisp inputs are changed to fuzzy inputs with the use of membership functions. For properly adapting the output fuzzy inference sub-procedure uses if-then rules during fuzzy inference. These rules determine the output. During aggregation, sub-procedure minimum of membership function of all inputs is determined for each rule. Results of aggregation sub-procedure are used for composition. A membership function for each region of the output parameter is calculated using the rule base and the values determined in the aggregation step. Min-max procedure is used for composition. During defuzzification subprocedure, the fuzzy output values are converted into real numbers. The defuzzification method used in this work is Weight-of-Average-Formula.

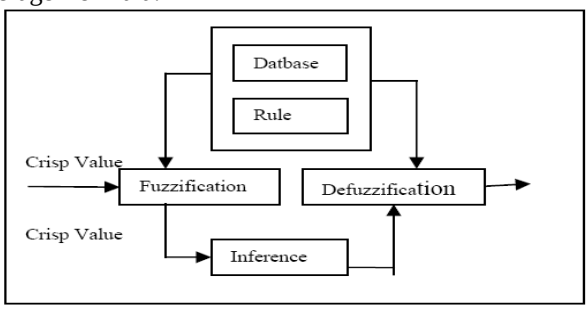

Figure 1: General Structure of Fuzzy Logic based Decision Support System

IV. DESIGN OF THE SYSTEM

Fuzzy decision support system designing, membership functions, fuzzy rule base, fuzzification and defuzzification are described in this section. In the proposed system a total of three inputs are chosen which determines the output.

A. Input Variables

1. Maximum length of vehicles behind traffic light

Maximum length of vehicles behind traffic light plays a vital role in traffic control at the junction. We have considered the time duration for red light as 60 seconds This time is considered for measuring the length. In our case, we have taken four ranges of this parameter; very small, small, medium and long. Fuzzy sets for input variable maximum length of vehicles behind traffic light are shown in Table 1. Figure 2 shows the membership function of this input.

Table 1: Fuzzy sets for Input variable Maximum length of vehicles behind traffic light

Linguistic variable	**Range**	**Fuzzy sets**
Maximum length of vehicles behind traffic light	0-4	Very small
	0-8	Small
	4-12	Medium
	More than 8	Long

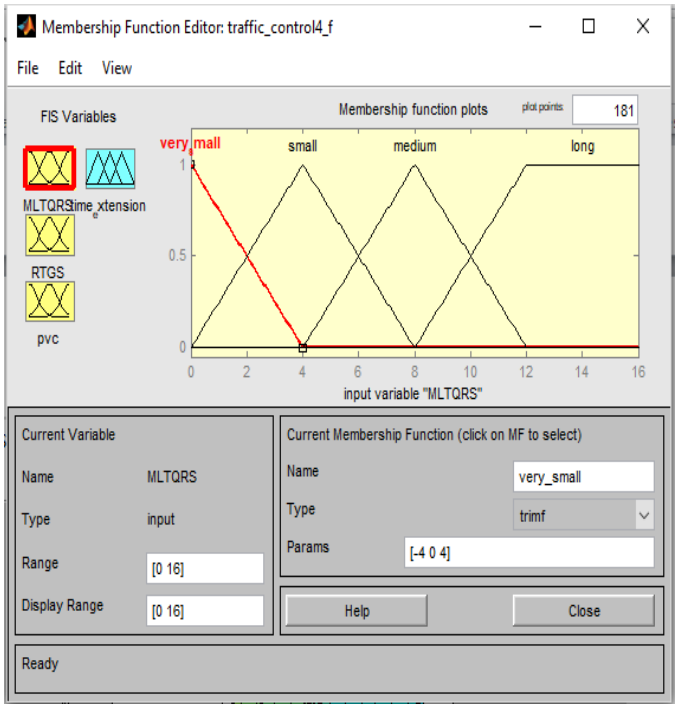

Figure 2: Membership function of the input Maximum length of vehicles behind traffic light

2. Left green time

Left green time when there is no traffic plays a vital role in traffic control at the junction. In our case, we have taken four ranges of this parameter; very few, few, medium, and long.

Table 1: Fuzzy sets for Input variable left green time

Linguistic variable	**Range**	**Fuzzy sets**
Left green time	0 – 0.25	Very few
	0 – 0.5	Few
	0.25– 0.75	Medium
	0.5 – 1.0	Long

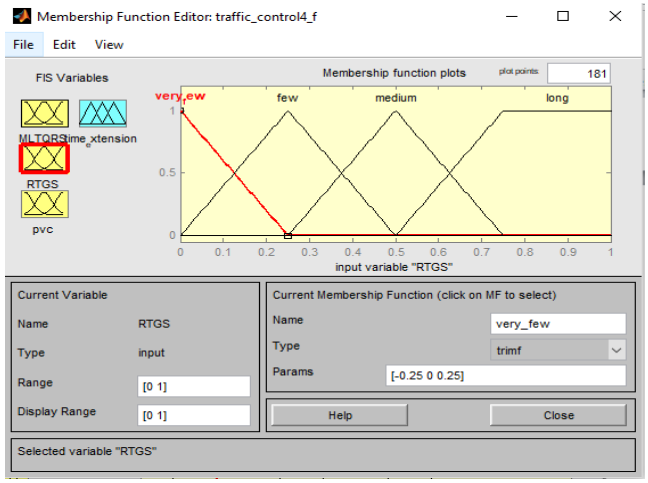

Figure 3: Membership function of the input Left green time

3. No. of vehicles reaching the traffic light in a short period of time

No. of vehicles reaching the traffic light in a short period of time also plays a vital role in mitigating the congestion at the junction point. The time considered here is quite short, 10 seconds. From the first input point of view, i.e. Maximum length of vehicles behind traffic light, this third parameter is used to give an accuracy this this first input. In our case we have taken three ranges; few, moderate and high. Fuzzy sets for input variable "No. of vehicles reaching the traffic light in a short period of time" are shown in Table 3. Figure 4 shows the membership function of this input.

Table 3: Fuzzy sets for Input variable No. of vehicles reaching the traffic light in a short period of time

Linguistic variable	Range	Fuzzy sets
No. of vehicles reaching the traffic light in a short period of time	0 – 4	Few
	4 – 8	Moderate
	4 – 15	High

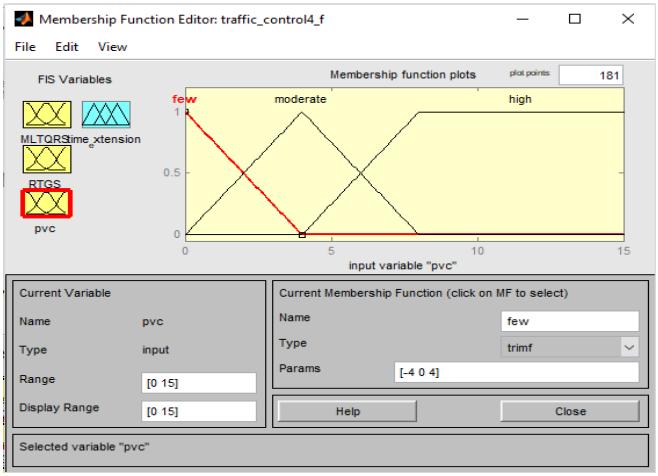

Figure 4: Membership function of the input No. of vehicles reaching the traffic light in a short period of time

B. Output Variable

Aim of the present work is to reduce the congestion at the junction points of traffic light so as to save time, fuel and possibility of accidents. The output variable, extension, has a value from 1 to 5; representing more decrease, decrease, do not change, increase, and more increase. Here increase or decrease is from the already set or left time of the light.

C. Fuzzy Rule Base

The rule base determine the extension, having five different values; more decrease, decrease, do not change, increase, and more increase. Figure 5 shows the Rule Viewer.

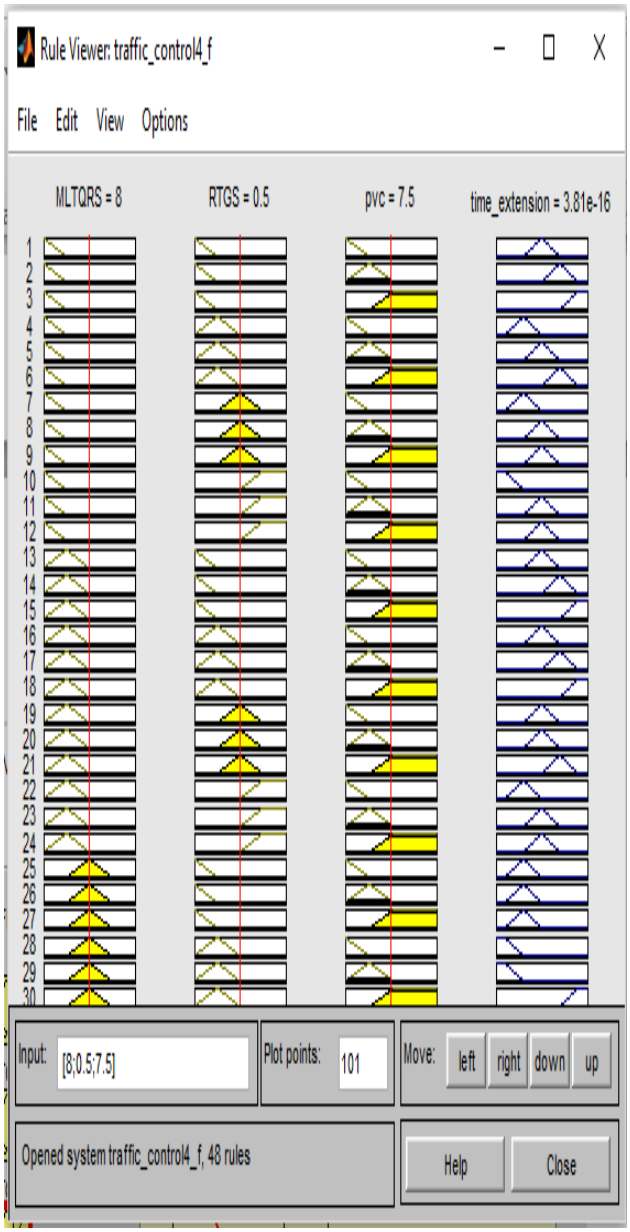

Figure 5: Rule Viewer

D. Fuzzification & Defuzzification

This system depends on Mamdani model for inference mechanism. Aggregation method between rules is maximum to combine output fuzzy set. Fuzzification method used is min-max and defuzzification method is centroid.

E. Surface Viewer

Different surface viewer are shown in figure 6 - 8. Figure 6: shows the surface viewer of Maximum length of vehicles behind traffic light, Left green time, and output extension. Figure 7 shows the surface viewer of Maximum length of vehicles behind traffic light, No. of vehicles reaching the traffic light in a short period of time and output extension. Figure 8 shows the surface viewer of Left green time, No. of vehicles reaching the traffic light in a short period of time and output extension.

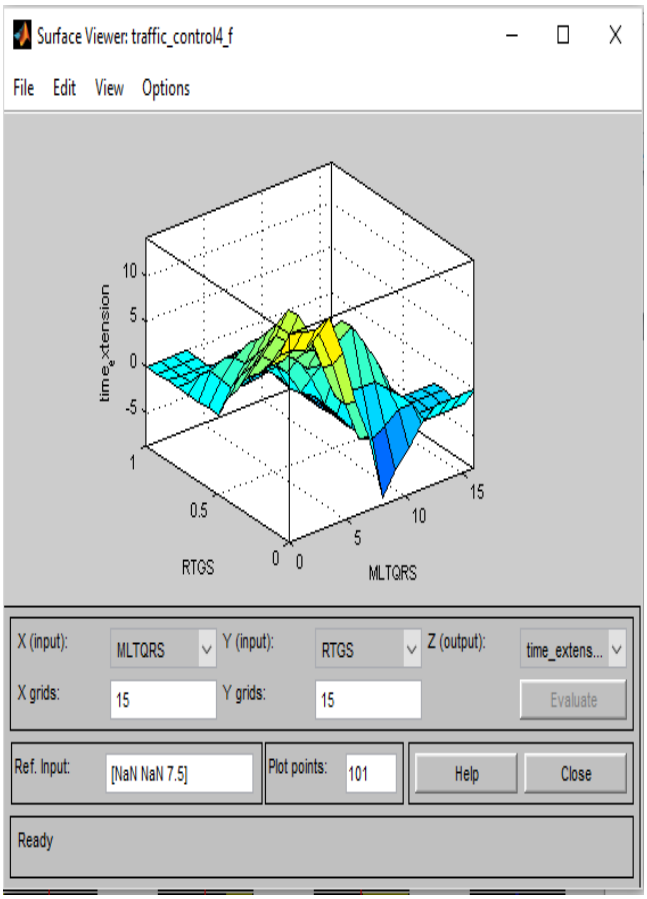

Figure 6: Surface viewer of Maximum length of vehicles behind traffic light, Left green time, and output extension

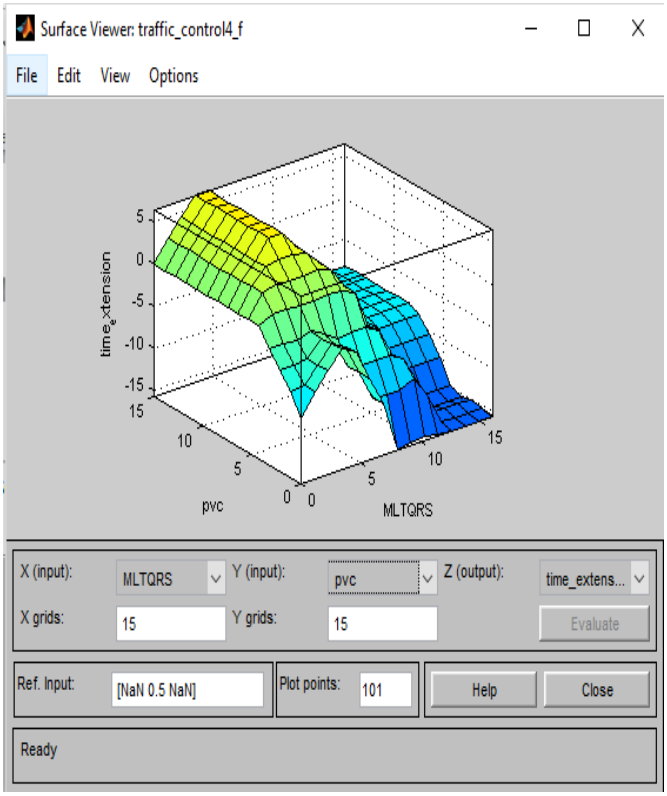

Figure 7: Surface viewer of Maximum length of vehicles behind traffic light, No. of vehicles reaching the traffic light in a short period of time and output extension

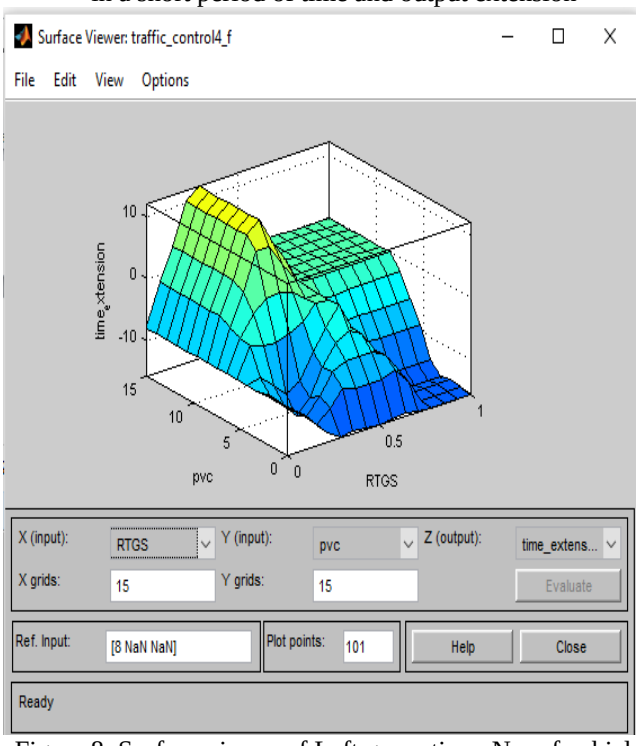

Figure 8: Surface viewer of Left green time, No. of vehicles reaching the traffic light in a short period of time and output extension

V. CONCLUSION & FUTURE WORK

Traffic congestion at the traffic light junction has been a very huge problem all around the world in terms of delay, extra fuel consumption and most importantly the high risk of increased probability of accidents. In most parts of the world, a static timer is used for controlling the traffic lights which gives a lot of problems from accuracy point of view. This work proposed a fuzzy logic based decision support system for intelligent traffic control system. It focused on the algorithm used to reduce the time spent extra on the traffic light junction so as to save the fuel, time and to reduce the possibility of accidents occurring at the traffic light junction. The proposed system used three input parameters; namely maximum length of vehicles behind traffic light, left green time, and no. of vehicles reaching the traffic light in a short period of time and one output, extension time which is used to control the congestion at the traffic light junction. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine is used to deduce from the input parameters.

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