A NEW APPROACH FOR FUZZY TRAFFIC SIGNAL CONTROL

Yetis Sazi Murat
Pamukkale University, Faculty of Engineering, Civil Engineering Department
20017 Denizli / TURKEY
E-mail: ysmurat@pamukkale.edu.tr

Ergun Gedizlioglu
Istanbul Technical University, Faculty of Civil Engineering, Transportation Department
80686 Istanbul / TURKEY
E-mail: egedizlioglu@srv.ins.itu.edu.tr

1 INTRODUCTION

While controlling the traffic flows at signalized intersections, it is aimed to decrease delays of vehicles and environmental effects and also increase intersection capacity at same time. Because of this, traditional control methods are insufficient and new methods which optimise the explained purposes are needed.

Fuzzy logic is one of these new methods as mentioned above. It was introduced in 1960 by Lutfi Akerzade (Zadeh) at University of California (Berkeley) and it was based on set theory. Earlier of 1970’s, applications of this method are much less but after 1990’s, applications of method are widely used all over the world. Traffic signal control is also one of these applications (Pappis and Mamdani 1977, Nakatsuyama et. all 1984; Tzes Mcshane and Kim 1995, Niittymaki 1998).

In this paper, a new approach for fuzzy logic signal control is considered and a model which contains a fuzzy logic phase sequencer is developed. Performance of the fuzzy model is investigated by simulation studies and is compared with traffic actuated control method.

2 FUZZY LOGIC TRAFFIC SIGNAL CONTROL MODEL FOR ISOLATED INTERSECTIONS

2.1. Aim of the Study

Fixed time and traffic actuated control methods are used for controlling the isolated signalized intersections. If traffic volumes are fluctuating in time of day the traffic actuated model is chosen but if traffic volumes are stationary in time of day then fixed time control model is used. Although traffic actuated control is used efficiently, some problems can be seen because of the structure of system and delays of vehicles are increased. In this study, a new signal control method which is based on fuzzy logic is developed for optimum control of fluctuating traffic volumes.

2.2. Structure of the Model

The fuzzy logic traffic signal control model which is developed for multi-phased controlled isolated intersections contains a fuzzy logic signal time controller system and a fuzzy logic phase sequencer system. Both of these systems are based on different rule bases. In these
systems, the control of traffic volumes are achieved by using impulses of detectors that are set on approaches of intersection. Both systems contain some input and output parameters. General structure of fuzzy logic signal control model is shown in Figure 1.

![Figure 1. General structure of fuzzy logic signal control model.](image)

### 2.2.1. Control Parameters of Fuzzy Logic Signal Time Controller

According to impulses of detectors that are setting on approaches, decision of signal time changing (e.g. extension or not), and changing of phase sequence are resulted.

Fuzzy logic signal time controller and phase sequencer consist of some input and output parameters that are selected for representing the system. Input and output parameters are as follows.

**Input parameters of fuzzy signal time controller:**
- Longest Queue in Red Signal (very few, few, medium, many)
- Approaching Vehicles (number of vehicles) in Green Signal (very few, few, medium, many)
- Remaining rate of Green Signal Time (Green time indicator) (very few, few, medium, many)

**Output parameter:**
- Decision of Signal Time Changing Amount (more decrease, decrease, no change, increase, more increase)

**Input parameters of fuzzy phase sequencer:**
- Longest Queue in Red Signal (very few, few, medium, many)
- Longest Queue in Next Phase (few, medium, many)
- Changing Time of Longest Queue in Red Signal (few, medium, many)

**Output parameter:**
- Changing Decision of Next Phase (no change, change)

Combination of input and output variables are considered in rule base. Two rule bases are considered in the model. Generalized modus ponens (GMP) method is used for developing of
rule base. Some rules are also added this rule base for increasing efficiency of controller performance.

3 INVESTIGATING OF FUZZY LOGIC SIGNAL CONTROL MODEL PERFORMANCE

Performance of Fuzzy Logic Signal Control Model is investigated using simulation studies. Fuzzy logic signal control model is compared with traffic actuated model for two and three phased controlled intersections with respect to average delays and number of stops of vehicles. Average delay values are calculated by using weighted average method considering traffic volumes of approaches and it is expressed as seconds per vehicle unit for each flow. Number of stops values are calculated by using deceleration and stopping delay values of traffic flows. Comparisons are done by considering two cases of traffic volumes; equal and different (not equal) values at approaches of intersection. Results for two phasing situation are given in Figure 2 and Figure 3, respectively.

Figure 2. Comparison of fuzzy logic model values with traffic actuated model values for two phasing control and equal traffic volumes.

Figure 3. Comparison of fuzzy logic model values with traffic actuated model values for two phasing control and different (not equal) traffic volumes.
Second situation which is considered for researching the performance of the fuzzy logic controller is not equal or different traffic volumes on approaches of intersection at the same time. Some experimental studies are made for determining considered traffic volumes and results of comparisons are indicated in Figure 3.

Results for three phasing situation are given in Figure 4 and Figure 5, respectively.

According to the simulation studies, it is understood that results of the fuzzy logic controller is the same as the traffic actuated controller when considering two phasing controlled situation and little traffic volumes. But if the variation and values of traffic volumes are bigger, the fuzzy logic controller decreases the delays of vehicles and increases performance about 15 percent. When considered three phasing controlled situation, fuzzy controller also decreases the delays and increases the capacity for equal and different traffic volumes. In three phasing control situation the fuzzy logic phase sequencer system activated and proper phase sequence selected.
4 CONCLUSIONS

In this study, a dynamic signal control model which is based fuzzy logic is developed. Validation of the fuzzy logic control model is investigated by using simulation techniques. To compare the model with traditional methods (traffic actuated control methods) some simulation models are designed.

Results of the study can be explained as follows:

1. A new approach is considered and a fuzzy phase sequencer is developed with this model. This sequencer model provides some advantages and selects proper phase sequence.
2. Simulation studies are done and some models are developed for searching validation of the fuzzy logic signal control model.
3. Two phased and three phased controlling situation is considered for an intersection which have four legs and open for two way traffic in comparison of controller.
4. The fuzzy logic signal control model is compared with the traffic actuated model for delays of vehicles parameter considering two and three phased controlling situation.
5. Results of comparisons for two phased controlling situation and equal traffic volumes at lanes of intersection show that, the fuzzy logic signal control model is the same as traffic actuated control when traffic volumes are equal or less than 800 vehicles per hour. However if traffic volumes are more than 800 vehicles per hour the fuzzy logic signal control model has some advantages to the traffic actuated control and decreased performance values about 22 percent.
6. It is understood from the comparisons that while two phasing controlling situation is considered and the traffic volumes of lanes are different and differences are very big, the fuzzy logic signal control model has decreased delays of vehicles about 15 percent according to traffic actuated control model.
7. Results of comparisons for three phased controlling situation and equal traffic volumes at lanes of intersection show that, the fuzzy logic signal control model is the same as traffic actuated control when traffic volumes are equal or less than 600 vehicles per hour. However if traffic volumes are more than 600 vehicles per hour the fuzzy logic signal control model has some advantages to the traffic actuated control and decreased performance values about 16 percent. According to the results, while the traffic volumes of lanes are different and differences are very big, the fuzzy logic signal control model has decreased delays of vehicles about 23 percent according to traffic actuated control model.

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