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INTELLIGENT TRAFFIC SIGNALS USING FUZZY LOGIC CONROL

SANAL.R.P
National Transportation Planning and Research Center
Thiruvananthapuram

Abstract

Traffic congestion represents the one of the major problems caused by increasing use of automobiles in cities. Traffic congestion causes significant decrease in both traffic throughput and travel speed. The conventional stop and go driving regime cause increase in accident frequency, level of fuel consumption, air pollution and time loss. This paper is an attempt to explore a new method based on fuzzy logic to improve the flow.

1. Introduction

Every automobile driver is faced with three levels of information processing and control

1. processing of information generated inside the vehicle
2. processing of information generated in the immediate visible environment
3. processing of information on the traffic situation in the peripheral(Not Yet Visible) environment

Traffic signal control, displaying the control information by means of traffic lights, route signs can establish an explicit link between the peripheral and immediate environment. Here we consider a single intersection of two one-way streets.

The present study focuses on junction control in a single isolated intersection. The system has the following sub-systems. The figure 1 shows a schematic diagram of the control system.

1. Information Collection Units: Traffic flow detectors to get the control parameters, viz., traffic volumes, mean speeds, traffic densities and headway between vehicles.
2. Local Information System : Electronic devises that evaluate detector measurements and control traffic lights
3. Information Display System: Controllable Traffic Signals

In traffic responsive signal plan generation the most appropriate signal setting are obtained by on-line calculations based on the detector measurement.

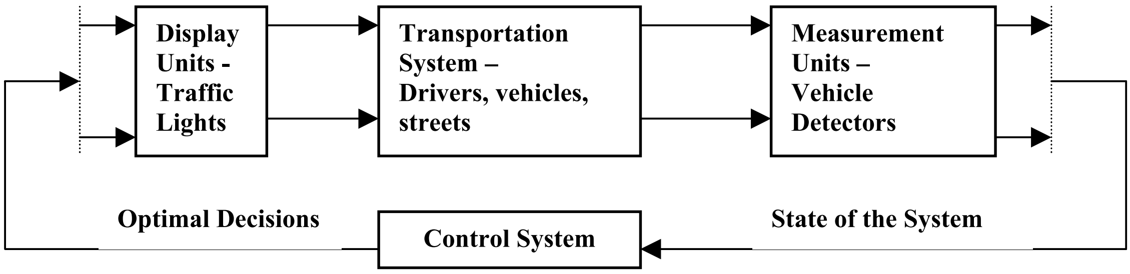

Figure 1 Schematic diagram of a Traffic Control System

Fuzzy Logic : Fuzzy Logic is a technology that translates natural languages description of design policies in to an algorithm using a mathematical model. This mathematical model implements the flexibility of human logic – abstraction and thinking in analogies in engineering solutions. This model consist of following three major sections:

- **Fuzzification :** Fuzzification means using the Membership Functions of Linguistic Variables to compute each term's degree of validity at a specific operation point of the process.
- Fuzzy logic **Inference** using IF-THEN rules**:** All numerical values have to be converted into linguistic values. Production rules consist of a condition (IF-part) and a conclusion (THEN-part). The IF-part can consist of more than one precondition linked together by linguistic conjunctions like AND and OR. Each rule is assigned a Degree of Support in the interval [0,1] representing the individual importance of the rule. The validity of a conclusion is calculated by a linking of the validity of the entire condition with the degree of support by a composition operator.
- **Defuzzification :** Membership functions are used to retranslate the fuzzy output into a crisp value. This retranslating is known as defuzzification. First a typical value is computed for each term in the linguistic variable and finally a best compromise is determined by balancing out the results using different methods like center of maximum(CoM), center of area (CoA), mean of maximum (MoM), etc.

2. System Development Methodology

The development methodology used here has the following steps:

Step 1: System Design: The system design covers the Definition of Linguistic Variables, Types of Membership Functions, Creation of a Rule Base, Identification of the appropriate Defuzzification Method.

The fuzzy sets in the present study are the following:

1. Time since last Change(TLC) ε {short, medium, long}
2. No. of arrivals through green ligh(ATG) ε {low, medium, heavy}
3. No. of vehicle waiting in the queue (VWQ) ε { low, medium, heavy}
4. Extension of time before the light is to be changed (ETC) ε { short, medium, long}

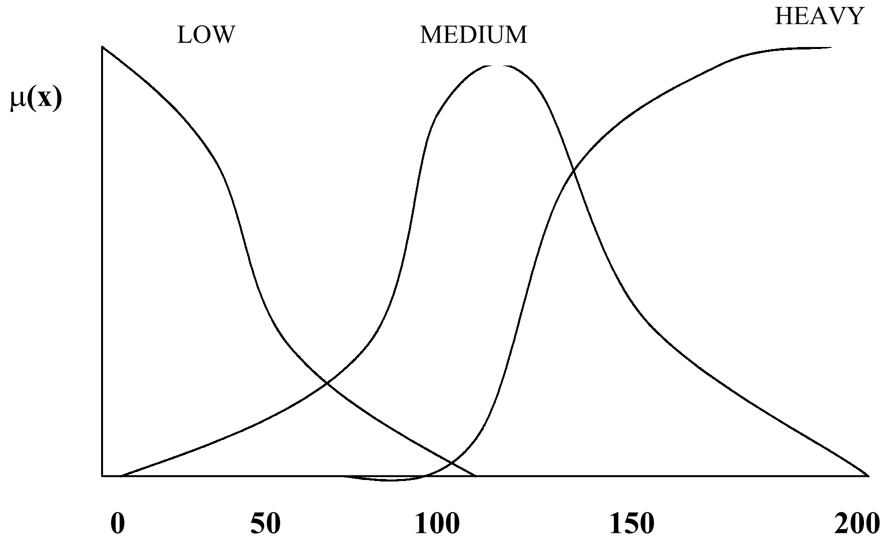

Figure 2 Membership Function of Traffic density

A fuzzy control rule of following type is adopted in the system.

Rule α

IF TLC is Medium
AND ATG is Heavy
AND VWQ is Low
THEN ETC is Medium

with a degree of support(DoS) in the interval [0,1]. Using the product operator for composition, the result of the rule would be: PROD{ Degree of Validity of the Condition, Degree of Support} = Result of the Rule or Validity of the Consequence. If the degree of validity of condition is 0.8 and DoS is 0.8 then the result of the rule is PROD{0.8,0.8} = 0.64.

The decision to extend the green light by the time increment Δt is based on the evaluation of a cost function Q which is defined as follows:

$$Q_A = G_A(\delta_{Ai}) - L_B(n_{Bj})$$

Where Q_A is the gain obtained for phase A and L_B is corresponding loss from an enlargement of phase A by Δt seconds for B, δ_{Ai} describes the number of additional cars that can pass the intersection if the green light is extended by Δt seconds and n_{Bj} denote the number of queuing cars in approach B that will suffer an increased delay of Δt seconds if the green is extended. GA and LB can be calculated as follows (Bang and Nilsson(1976)):

$G_A = r_A[ai\delta_{Ai}]+bv\delta_{Ai}$ and $L_B = \Delta t[ajn_{Bj}]+bvn_{Bj}$

Where r_A is the time interval between red and green for phase A to get a green light again if it is terminated immediately; ai cost of delay per second for cars and bv are vehicle operating costs to bring a car to complete stop and to resume normal speed. The decision to extend phase A is made by the following rule:

$$Q_A = \begin{cases} \geq 0, \text{ extension of the running phase A} \\ < 0, \text{ change to the phase B} \end{cases}$$

Every 10 seconds, a different set of control rules will be evaluated by controller for times equal to 1 through 10 s in order to determine the time of continued extension of current state of light. The maximum time for a green light can be set to 57 s. A decision table can be used to select a crisp control action which assigns each crisp extension time a degree of confidence. Controller will choose the extension time that maximizes the confidence level.

Step 2: Off-Line Optimization : In the second development step you simulate and test the prototype designed in the first step. The technologies that you use here depend very much on the application type. The off-line optimization step is completely supported by software development tools like *Fuzzy* TECH®.

Step 3: On-Line Optimization : For many closed loop control systems you cannot use simulation techniques because no good mathematical model for the process exist

Step 4: Implementation : After completion, the fuzzy logic system can be implemented on target hardware platform. The figure 3 shows the schematic representation of the system.

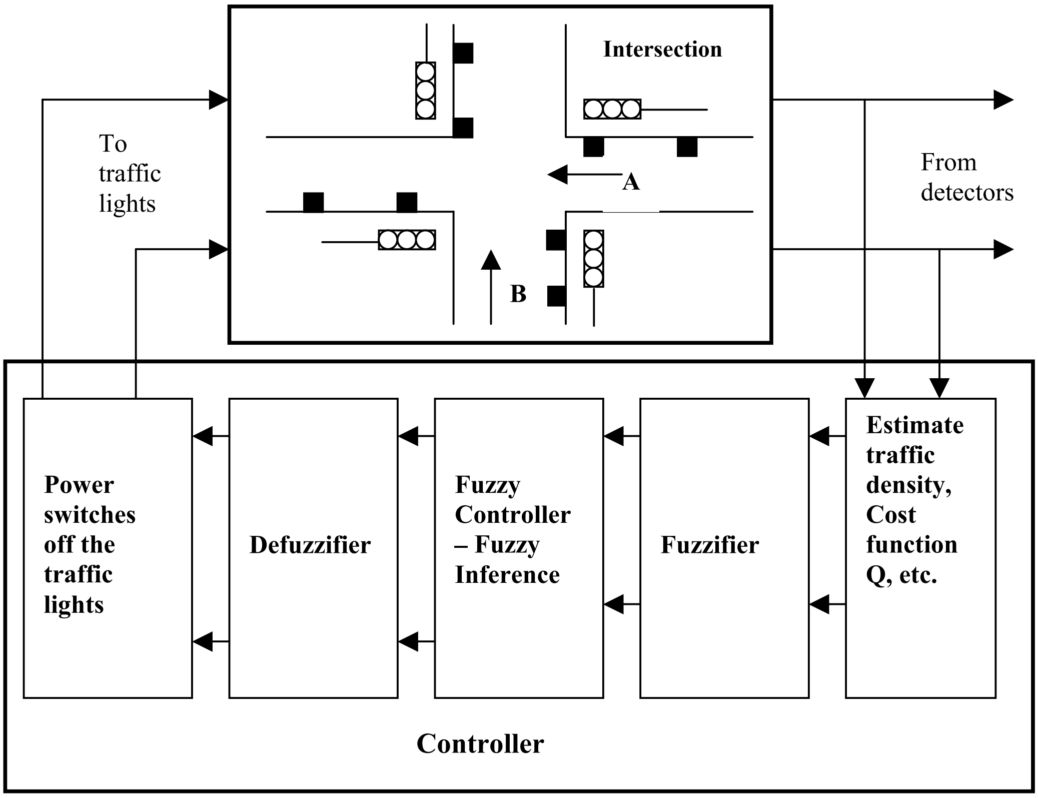

Figure 3 Schematic Diagram of the Fuzzy Logic System

3. Conclusion

The implementation of the system require higher installation costs because of the use of detectors. Under complicated conditions the implementation of the system can become useful and can give substantial reductions in average delay and the proportion of stopped vehicles as compared with conventional fixed time control. The key benefit of the system is that it allows to describe the desired behaviour with IF –THEN relations. Here the relations has to be derived manually, which with large datasets require major effort - some trial and error is needed in order to create a set of satisfactory fuzzy control rules - is one of the major limitation of this methodology. A neural network promises a solution since it can train itself from the data sets.

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