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Electro Sensitive Traffic Light using Fuzzy Look Up Table

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Abstract:

Nowdays, with increasing many vehicles on restricted roads, the conventional traffic light creates prove startup-delaytime and end-lag-time. The conventional traffic light loses the function of optimal cycle. And so, 30-45% of conventional traffic cycle is not matched to the present traffic cycle. In this paper proposes electrosensitive traffic light using fuzzy look up table method which will reduce the average vehicle waiting time and improve average vehicle speed. Computer simulation results prove that reducing the average vehicle waiting time which proposed considering passing vehicle length for optimal traffic cycle is better than fixed signal method which dosen't consider vehicle length.

Keywords Conventional traffic light, Vehcile length , Optimal traffic cycle, Fuzzy rule

I. Introduction

After Dr. zadeh proposed the fuzzy theory and fuzzy logic, the application of the fuzzy set theory and fuzzy logic have been increased and widely used in many fields. In this paper, we proposed optimal traffic signal light using fuzzy rules and fuzzy look up table. Perhaps, the best traffic signal light would be one run by a policeman skilled at traffic control. It is not possible to work every intersection 24 hours a day. Thesedays, the role of the traffic signal light is very important when the volume of traffic can't be predicted. When there are a lot of running vehicles at a crossroad, the signal cycle should be extended . When there are few running vehicles, the signal cycle, should be shortened. In order to produce optimal signal cycle we must first check how many waiting cars are at the lower intersection, because waiting queue is bigger than the length of approach When there are few running vehicles, the signal cycle should be shortened. In order to produce optimal signal cycle, we must first check how many waiting cars are at the lower intersection, because waiting queue is bigger than the length of approach load, spillback occurrs and wating queues occupy the intersection. Also, offset decision in the traffic intersection becomes different at each signal by the waiting queue for the rest of the vehcle which don't pass the upper traffic intersection within green time among the vehicle that passed the lower traffic intersection. Therefore in this paper, we can create the optimal traffic signal using fuzzy control. Electro sensitive traffic light has a better efficiency than fixed preset traffic signal cycle because it is able to extend or shorten the signal cycle when the number of vehicles increase or decrease suddenly. To prevent spillback and improve vehicle waiting time, In this paper, we designed an optimal traffic signal light board using fuzzy look up table.

II. Vehicle waiting time

The mean volume of vehicles in the waiting line throughout the whole time is as follows.

$$Q = \frac{D}{C} = \frac{CR^2}{2C\,(1-Y)} \qquad \text{........................(1)}$$

$$D = \frac{D}{QC} = \frac{R^2}{2C\,(1-Y)} \qquad \text{........................(2)}$$

As for 'ALL SOP', when arriving traffic is not successive function but STEP FUNCTION that has the interval of mean 1/Q. Mean vehicle delay can be explain Eq. 3.

$$D = \frac{1}{2C\,(1-Y)}\left(R - \frac{1}{2S}\right) + \frac{Y(2-Y) + Q(1-Y)}{12Q} \qquad \text{............(3)}$$

S : Congested traffic volume on one approaching road (PCU/second)
Q : Mean arriving traffic rate on one approaching road
C : Cycle length (second)
D : Mean vehicle delay per PCU on one approaching road (second)
R : Effective redlight time (second)
Y : Ratio of mean arriving rate to congested traffic volume Q/S

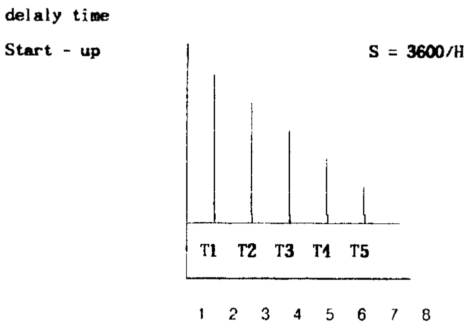
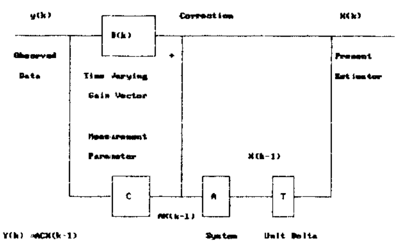


Fig. 1 Vehicle Volume in Waiting Line



A = Transition Matrix on System Equation

C = Transition Scala on Observation or Measurement Equation

Optimum Recursive Estimator Filter

FIG 2. Kalman Filter Technique of traffic intersection

$$A = (1 - \beta) \times A(t) + \beta \times A(t-1)$$

$$A = A' + \text{Noise}$$

$$= (1-a) \times Exp(-bxT) + a$$

A = Real traffic vehicle data

β = Exponential Filter

A' = Underlying true traffic volume

As a result, the delay time of all cars on each road of the intersection during one cycle will be as follows;

$$D = D_{N\text{-}R} + D_{N\text{-}G} \qquad \text{........(4)}$$

$$D_{N\text{-}R} = \sum_{n2=1}^{n}\left(Q_G + \sum_{n1=1}^{n2} Q_{N1}\right) \qquad \text{........(5)}$$

$$D_{N\text{-}G} = \sum_{n2=1}^{n}\left(Q_R + \sum_{n1=1}^{n2} Q_{N1} - S_N\right) \qquad \text{........(6)}$$

Further, average delay time per each car is as follows;

$$Dm = \frac{D}{\sum_{N=1}^{n} Q_N} \qquad \text{........(7)}$$

$D_{N\text{-}R}$ and $D_{N\text{-}G}$ are delay time during red light and that during green light respectively. Evaluation for reliance of model can be seen in comparison with time delay from optimal cycle control apparatus.

Conventional traffic signal system cause vehicle waiting time, reduce average running speed. Because this system has no function to extending, or reducing signal period by sudden vehicle stream.

Optimal signal period can be calculated by using Kalman filter method as shown in fig. 2 and fuzzy rule for deciding optimal offset as to preventing spillback phenomenon and to reducing vehicle waiting time. But predicate method of signal period has demerits by Kalman filter method that algorithm is not modeled correctly. This paper is studied by using neural network and 27 fuzzy rules as to preventing weak spillback phenomenon of highsaturation in ordinary fixed signal period method.

III. Vehicle waiting length

Overflow is defined in the period of i-1 as Q_{i-1}, the length of waiting vehicles in the end point of red time is found by summing the value of multiplying arriving rate by red time(r) to Q_{i-1}. When red time starts waiting vehicles outflow to saturated traffic rates and the starting wave created by the start of green time is transferred to the back as the velocity,w. During that time , arriving vehicle continue to the tail of stopping and waiting vehicles. After green time starts, green time starting wave reaches to the tail of waiting vehicles, then stopping and waiting vehicles is gone and all vehicles on the link get moved.

The maximum length of waiting vehicle is defined as the number of stopping vehicles from stopping line to the point of the last stopping vehicle. If it is estimated the maximum length of waiting vehicles as MAXQi, by arriving rate

$$MAXQ_i=Q_{i-1}+v \cdot (r+t) \qquad \text{......(8)}$$

where,

Qi-1 : the length of waiting vehicles in the end point in period i-1

v : arriving rate

r : red time

t : lap time of red time by start and velocity

$$MAXQi=w \cdot t \qquad \text{.....(9)}$$

where,

w : starting wave caused by green time overflowing to saturated traffic rate

t : lap time of green time

from eq. (8) and eq. (9)

$$t=(Q_{i+1}+v \cdot r)/(w-v)N \qquad \text{.....(10)}$$

$$MAXQ_i=Q_{i-1}+v[r+(Q_{i-1}+v \cdot r)/(w-v)] \qquad \text{....(11)}$$

where,

w : starting wave caused by green time overflowing to saturated traffic rate

v : arriving rate

or

$$MAXQ=w \cdot (Q_{i-1}+v \cdot r)/(w-v) \qquad \text{...(12)}$$

We can estimate the maximum length of waiting vehicles when understanding all the overflow at the period starting point and velocity caused by green time arriving rate, saturated overflow. But in signal control system the information about the length of waiting vehicles is limited at the past information then it must be estimated the length of waiting vehicles. Therefore, we must evaluate the model that estimate the maximum length of waiting vehicles obtained from real traffic conditions. If it is called the evaluated the maximum length of waiting vehicles in period i-1 and period i as $MAXQ_{i-1}$, $MAXQ_i$, arriving rate v_i is obtained as the following.

$$Q_{i-1}=MAXQ_{i-1}+(g-t) \cdot v_i-s \cdot g \qquad \text{.....(13)}$$

If maximum waiting queue is measured in each period, arrival rate is determined corresponding to the period. The accurate arrival rate is not estimated in each period, because of irregular traffic quantity. Therefore the next period arrival rate is estimated with previous arrival rate smoothing.

Moving average of previous 3 period is obtained with next period arrival rate. So, estimated arrival rate in next period is :

$$Vi=\frac{Maxqi-Maxqi-1/s*g}{Maxqi-Maxqi-1/w+c} \tag{14}$$

Where,

w: Green start wave during saturated traffic rate

s: Outflow rate of saturated state

C: Traffic signal period

MAXQ Q_{i-1} : measured waiting queue length of (i-1) period

MAXQ Q_i : measured waiting queue length of i period

Vi : arrival rate

If maximum waiting queue is measured in each period, arrival rate is determined correspond to the period. But, it is not impossible to estimate accurating arrival rate in each period, because of irregular traffic quantity. Therefore next period arrival rate is estimated with previous arrival rate smoothing as shown in fig. 2.

Moving average of previous 3 period is obtained with next period arrival rate. So, estimated arrival rate in next period is :

$$FV_{i+1}=\frac{V_{i-2}+V_{i-1}+V_i}{3} \tag{15}$$

If outflow rate in saturated state and start wave velocity at green signal is fixed, optimal offset is determined. The offset obtained from maximum waiting queue that is minimized slow and stop time, when the car go on from precedence cross-road to subordinary cross-road. But, waiting queue by vehicle change coefficient is not regular in actual traffic situation. Therefore, to estimate optimal traffic cycle, We must design Fuzzy traffic light board using 27 fuzzy rules as shown in Fig 3.

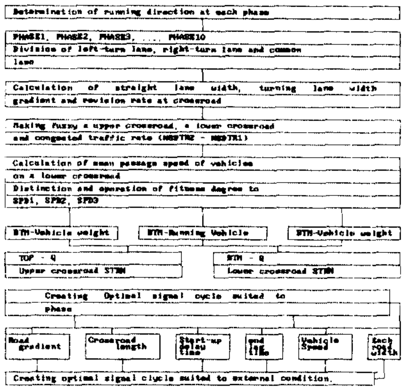


Fig 3. Flowchart of fuzzy traffic signal light

When a waiting line has more than N vehicles, at every time when the waiting line is given a greenlight signal every vehicle wastes H seconds and another seconds as much as L1 of whole loss time as shown in table 1.

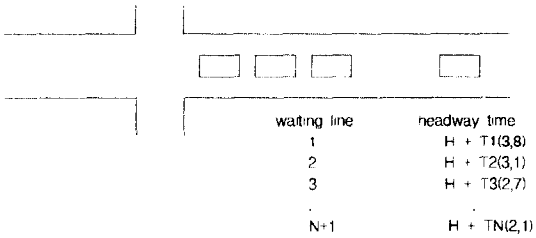


Fig 4. Vehicle waiting time in the traffic light

Table 1. Vehicle startup delay time in the traffic light

Vehicle Order	Position at 6 second (M)	Position at 8 second (M)
3	344.70	380.56
4	276,67	304,39
5	234,93	261,21
6	100,33	222,97
7	119,85	153,45
8	[illegible],83	111,75
9	26,67	54.43

Ⅳ. Fuzzy Traffic board using Lookup table

Array-1 in Block-A needs three pieces of 256-byte memory IC. In general, necessary memory ICs (MIC1) for N-input are:

INPUT				OUTPUT	
	TSP	TPR	TWT	OP	OS
0000	1-20	1-30	400-1000	1.5	3.0
0001	1-20	31-60	400-1000	1.3	3.0
0010	1-20	61-100	400-1000	1.2	2.8
0011	1-20	1-30	400-1000	1.5	3.0
0100	1-20	31-60	400-1000	1.3	3.0
0101	1-20	61-100	400-1000	1.2	2.8
0110	41-60	1-30	400-1000	1.5	3.0
:	:	:	:	:	:
11000	41-60	1-30	2001-4000	1.7	3.0
11001	41-60	31-60	2001-4000	1.6	3.2
11010	41-60	61-100	2001-4000	1.9	3.5

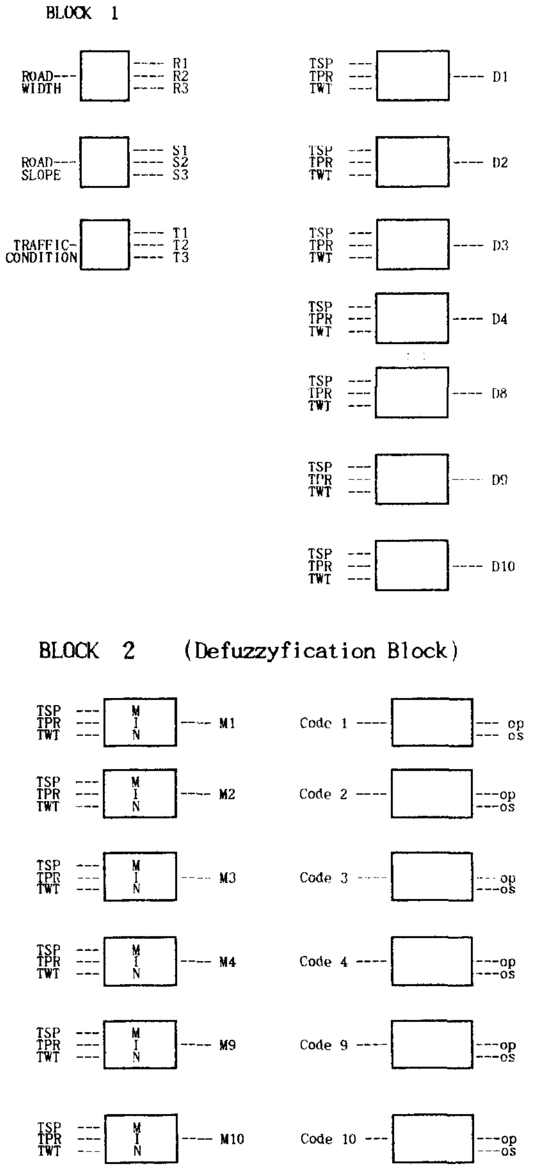


Fig 2. Blockdiagram of fuzzy traffic light using look up table

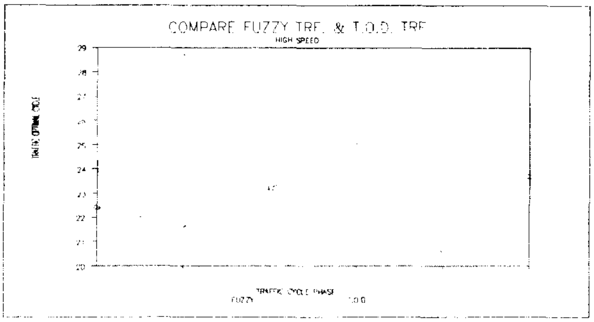


Fig 3 Comparisons between fuzzy traffic light waiting time for high saturation conventional traffic light

V. Conclusion

The fuzzy traffic controller shows reducing waiting time at the high saturated traffic condition. But in case of low saturated traffic condition, there are a little bit difference for reducing waiting time with vehicle waiting time of fuzzy traffic light and conventional traffic light. For the fuzzy controller, the average waiting time decreased by 15 percent when compared with the conventional controller. The fuzzy-controller simulation was compared with waiting time of T.O.D. signal light and fuzzy traffic light. In this paper, we can determine passenger car unit using 3 fuzzy membership and 27 fuzzy logic control rules. It proved that it can get the better results than the conventional signal don't have passenger car unit and offset. Finally, computer simulation confirms that vehicle waiting time gets improved by 10-15% even in case of spillback or large vehicles' sudden entry.

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