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Research of Intersection Traffic Signal Control and Simulation Based on Fuzzy Logic

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Abstract. In order to improve the traffic signal control for urban road intersection and reduce vehicle delay, the paper took the typical urban crossing signal control system as the research object and proposed a control algorithm based on fuzzy logic. Considering the traffic flow information as well as the length of vehicles on different approaches, the average delay hours had been selected out as the performance index. By using the control algorithm to improve the traditional fixed cycle length time distribution method of the intersection, the paper successfully designed a signal control system to adapt to various traffic conditions. By using Matlab software to analyze the data and simulate the effect, the results showed that this algorithm significantly reduced the traffic delay, achieved good control effect, and enhanced the capacity of the intersection. It has proved that the utilization of the control algorithm is a practical and effective method for the intelligent urban traffic control.

1. Introduction

Traffic congestion has seriously affected the quality of the urban environment and quality of life. The intersection is the node of the urban road network and the bottleneck of the urban road. Therefore, urban traffic signal control has become one of the research hotspots in the field of control and traffic engineering.

In our country, the method of timing signal control is widely used to divert traffic flow at road intersections, but traffic flow is transient, random and uncertain, etc. It is very difficult for the traditional timing signal control mode to distribute the traffic flow in each direction reasonably, to reduce the traffic congestion and to improve the traffic capacity at the intersection.

In order to find the best method to solve the traffic bottleneck problem at intersections, the fuzzy control algorithm adopted in this paper takes into account the road condition, real-time traffic flow and signal timing of signal control.

2. The status of intersection

2.1. Traffic condition of Intersection

The construction of Hainan International Tourism Island as a major strategic deployment of the country, the influence at home and abroad, the attractiveness is constantly expanding, Haikou as the provincial capital of Hainan Province, the traffic network system is increasingly large, the complexity of traffic is also increasing. Traffic jams are becoming more and more serious. Therefore, it is imperative to study the capacity of road intersections in Haikou city.

The intersection of Haidian Wuxi Road and Renmin Road is a typical horizontal cross intersection in Haikou City. The east and west entrance (Haidian Wuxi Road) are all three lanes connecting four







lanes. The north and south entrance (Renmin Road) are all connected by four lanes to five lanes, and the exit of the intersection are all three lanes. Each entrance road is equipped with a special right lane without a signal lamp. The width of the lane is 3.5 m.

2.2. Intersection traffic volume

According to the characteristics of traffic flow at the intersection of Haidian Wuxi Road and Renmin Road, the traffic volume at the rush hour (5:30-6:30) was counted by artificial observation. Each team is composed of 12 members. Each team is responsible for observing the traffic flow and traffic lights at a directional intersection.

Table. 1 Phase timing scheme in rush hour of intersection.

Phase1: The straight and left lane of Renmin Road north entrance	Phase 2: The straight and left lane of Haidian Wuxi Road east entrance	Phase 3: The straight and left lane of Haidian Wuxi Road west entrance	Phase 4: The straight and left lane of Renmin Road south entrance
			
G: 84s Y: 3s R: 278s	G: 79s Y: 3s R: 283s	G: 95s Y: 3s R: 267s	G: 95s Y: 3s R: 267s

Note: G stands for phase green time, Y for phase yellow light time and R for phase red light time.

According to actual traffic experience, the time of each phase should not be too short, lest the green time of a certain phase be too small, so that the vehicle cannot pass through the intersection in time and affect the traffic safety. Generally, the minimum phase time is 15 ~ 20 s, and the signal period should not be too long. Generally speaking, it can not exceed 220 s, otherwise it will make the driver psychologically unbearable because the green light time of a certain phase is too long. Generally speaking, when the delay is very small, the vehicle can run according to the minimum period. Therefore, we need to optimize the signal control system to improve the traffic capacity of the intersection and reduce the average vehicle delay time.

2.3. Simulation evaluation on the status of intersection

According to the existing traffic layout, traffic control measures and signal timing scheme at the intersection of Haidian Wuxi Road and Renmin Road, in the simulation evaluation results, the main parameters such as travel time, queue length and delay are selected to be simulated by MATLAB software. The resulting data is collated in Table 2.

Table.2 Simulation of intersection in rush hour under existing timing scheme.

Parameter	Driving state	Haidian Wuxi Road and Renmin Road			
		east entrance	west entrance	north entrance	south entrance
Average vehicle delay /s	Straight	152.8	117.9	93.2	113.4
	Left lane	142.8	124.8	93.6	105.3
Average parking number	Straight	0.72	0.95	0.57	0.75
	Left lane	0.69	1.02	0.63	0.75
Average queue length/m	Straight	120	64	81	65
	Left lane	129	50	75	43
Maximum queue length/m	Straight	203	180	236	176
	Left lane	246	220	221	117

The results are consistent with the traffic phenomena observed in practice, and the simulation model has a high reliability. According to the results and the actual situation, there are many problems in the intersection, such as too much delay, too many parking times, too long queue length and so on. The traffic jam is extremely serious.

Therefore, this paper will improve the traffic capacity of the intersection and increase the utilization of road resources by optimizing the signal timing scheme of the intersection.

3. Traffic signal simulation based on fuzzy logic

3.1. Fuzzy control algorithm

In this paper, a fuzzy control algorithm is proposed to optimize the signal phase control of intersections. It is to improve the time of the intersection with a fixed period. According to the traffic flow information, the intersections have rush hours. Both peak and off-peak intersections have green light times and periods that match them, which greatly enhance the scientific nature in line with the objective reality. The specific algorithms are as follows:

1. According to the actual traffic flow at the intersection, the minimum green time (G_{min}), the maximum green delay time (G_{max}) and the maximum queue length (L_{max}) of each phase are obtained, respectively, and the minimum signal period (T_{min}) and the maximum signal period (T_{max}) are determined.

2. The input variables of fuzzy controller are determined by collecting traffic flow data in each direction: traffic flow data X passing through intersection during green light period and traffic flow data Y which is stranded during red light period.

3. First give the current phase i the shortest green time $G_i = G_{min}$.

4. Select the phase with the highest traffic intensity from the current red light phase as the next green phase $i+1$.

5. At the beginning of the control, the queue length of the i phase and the queue length of the $i+1$ phase are obtained before the green time of i phase ends.

6. The difference between the i phase queue length and the $i+1$ phase queue length Δl is calculated, and two input variables of fuzzy control, namely L and Δl , are obtained by fuzzy reasoning. Get the green time of the current green phase g_i , if $g_i + G_i > G_{max}$, then $g_i = G_{max} - G_i$. The total green time of this phase is $G_i = G_{min} + g_i$.





7. The green time delay Δg is obtained by program calculation, that is, the time needed to extend this phase is extended, and the corresponding phase time control is carried out.

8. After the current green light prolongs the corresponding delay, switches to the next phase, circulates repeatedly in turn, thus realizes the intelligent control to the whole signal system.

3.2. Optimized timing scheme

According to the above principles, the system uses the fuzzy toolbox of MATLAB to compile the simulation program to optimize the signal control system of intersection. The optimized signal timing scheme is shown in Table 3, and the improved signal timing period is 182 s.

Table. 3 Optimization of phase timing scheme in rush hour

Phase 1:	Phase 2:	Phase 3:	Phase 4:
The straight and left lane of Renmin Road north entrance	The straight and left lane of Haidian Wuxi Road east entrance	The straight and left lane of Haidian Wuxi Road west entrance	The straight and left lane of Renmin Road south entrance
			
$G: 30s$ $Y: 3s$	$G: 40s$ $Y: 3s$	$G: 50s$ $Y: 3s$	$G: 50s$ $Y: 3s$

$R: 149s$

$R: 139s$

$R: 129s$

$R: 129s$

Note: G stands for phase green time, Y for phase yellow light time and R for phase red light time.

4. Analysis of simulation result references

The simulation results are obtained by using MATLAB software, and the optimization effect of the control algorithm is analyzed and evaluated, which provides a certain reference for the fuzzy-control mode realization of the signal control system of urban intersections in the future.

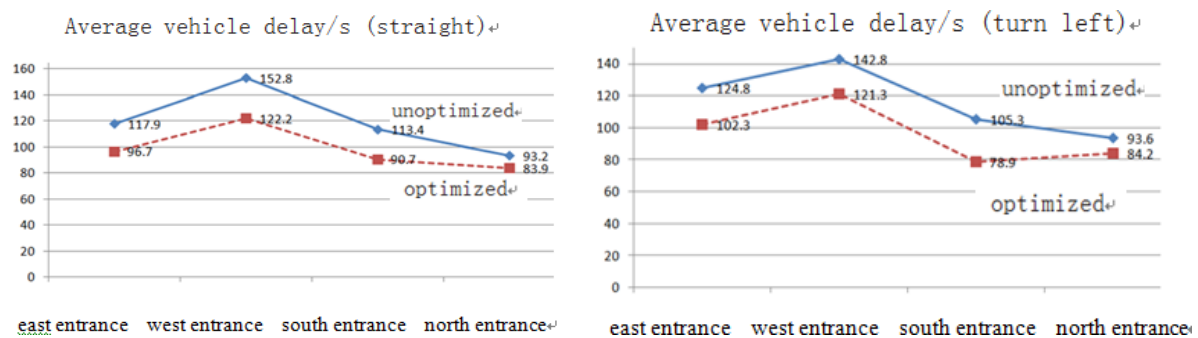


Figure.1 Comparison of optimized and unoptimized for average vehicle delay time of straight and left lane

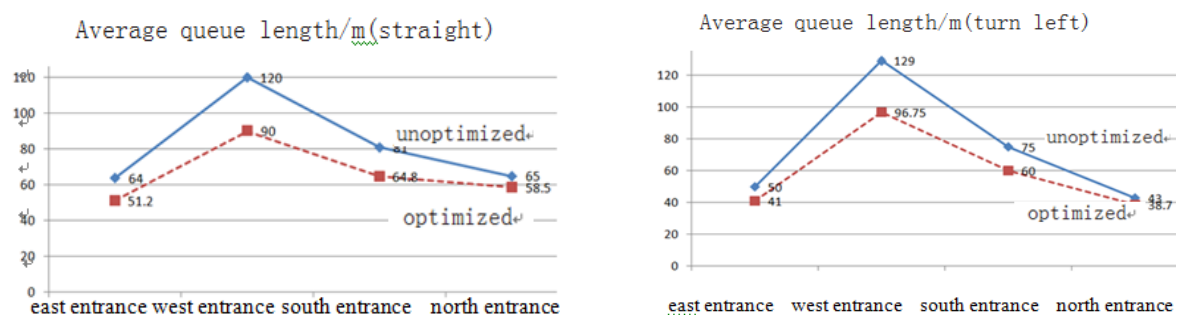


Figure.2 Comparison of optimized and unoptimized for average queue length of straight and left lane

After processing the data through the simulation results, Figure1, Figure 2, it can be directly seen that the intersection after the optimization of the straight and left turn through the intersection of the delay time has been significantly shortened, It can be seen that the fuzzy control algorithm proposed in this paper can better control the traffic flow, which can be based on the traffic situation of each phase, compared with the existing signal fixed period control of the intersection. The passage time of each phase can be determined flexibly, which can greatly improve the traffic efficiency of intersections.

5. Conclusion

Because the traffic flow of intersection is very random, the signal and phase control should change with the change of traffic flow. In this paper, a fuzzy control algorithm for intersection traffic control is proposed. At the end of each phase, the algorithm outputs the best green time of the next phase according to the detected queue length in real time, which can adapt well to the traffic characteristics of the intersection and provide some reference for the signal timing optimization of the intersection.

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References

- [1] PU Quan. Study on the application of fuzzy algorithm in intersection signal control[J]. Transportation Engineering. 2011,19 (10): 125-129
- [2] HE Yu, BIN Xinhua. Research on traffic fuzzy control system of urban single intersection[J]. Journal of Hunan Institute of Engineering.2009,19 (1):21-23
- [3] ZANG Lilin, JIA Lei, LIN Zhongqin. Research on traffic signal control and simulation based on fuzzy logic[J]. Journal of Highway and Transportation research and Development. 2006,23 (4): 124-127
- [4] ZOU Liang, PAN Zhou, CHEN Sheng. Intersection signal control Optimization based on vissim [J]. Modern Transportation Technology. 2014,11(2):64-67
- [5] LU Mingyu, WANG Xing. Intersection traffic congestion analysis and countermeasures[J]. Journal of Changchun University of Technology.2015,36 (3): 327-332
- [6] MilsonR, ColeyA, PravdaVandPravdovaA2004 Alignment and algebraically special tensors
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