The Design of Signal Control Software and Intersection Traffic Simulation

Hongke Xu[1, a] , Xiaoqing Hou[2,b], Rixing Zhu[3,c]

[1]School of Chang' an University, Xi' an 710000, China;

[2]School of Chang' an University, Xi' an 710000, China;

[3]School of Chang' an University, Xi' an 710000, China;

[a]xuhongke@chd.edu.cn, [b]houxiaoqing0525@126.com, [c]zhurixing@163.com

Keywords: intersection, traffic control, signal timing, traffic simulation.

Abstract. The current traffic signal lights often do not have flexible revise function, so it can't reach the real-time control requirements, and leads to increasingly serious urban traffic congestion, this control software presents an effective method to solve it by researching intersection traffic signal control. In this paper, intersection traffic signal timing control software and traffic flow microscopic simulation are designed. The software is implemented using the MFC programme. Simulation is based on SUMO. Through combining them, it can accomplish fixed timing control, multi-time control and adaptive control, which can adapt to different timing requirements and response to the current road conditions intuitively. By analyzing simulation result datas, it can be used for urban traffic signal timing optimization. To some degree, this software can ease the traffic congestion.

1. Introduction

Intersection is the key to improve urban traffic capacity. Signal timing optimization is one of the most direct and effective traffic control method. Reasonable traffic signal timing ensures good travel speed, comfort, safety, and environmental protection. So the study of traffic signal control method is of great significance. However, the relevant factors affecting traffic are numerous in practice. It requires a lot of money and implies much insecurity. In this case, traffic simulation will be very effective. It can intuitively show vehicle operation online and use result data to evaluate road conditions, which provides technical support for road planning. Therefore, the proposed design combines the intersection simulation system with control system, which can provide basis for signal timing optimization.

2. Design of intersection traffic signal timing control software

This design applies MFC programming to accomplishing single intersection signal timing control software. It provides human-computer interaction interface and make signal timing plan automatically. In addition, it can exchange data with simulation system. The running process is shown in figure 1.

2.1 Fixed timing control

This signal timing control software can accomplish fixed timing control that only uses one timing scheme. Also it can divide fixed timing into morning, noon, afternoon, evening according to different traffic volume, which is multi-time control. In this paper, timing algorithm of fixed timing control and multi-time control is alike. Timing algorithm process is shown in figure 2.

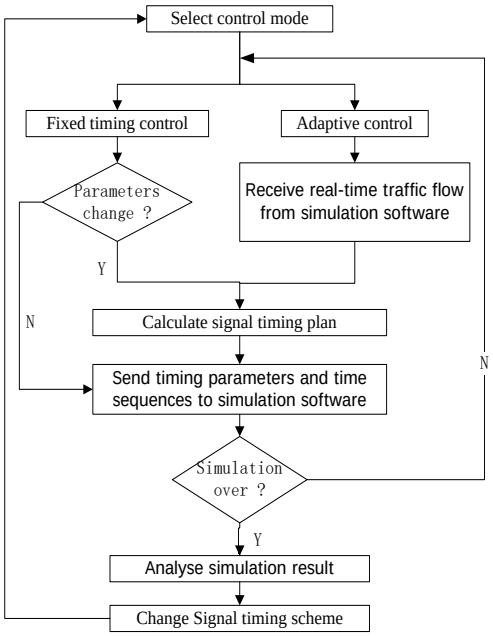


Figure 1.Signal timing control software running process

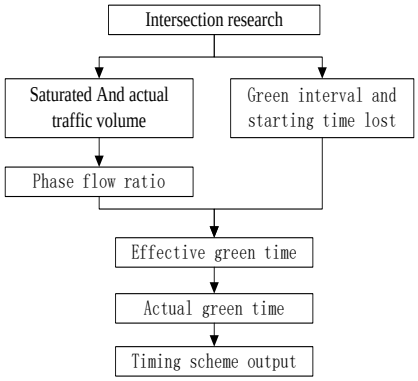


Figure 2.Timing algorithm process

After intersection research, it needs to calculate actual and saturated traffic volume, green interval and starting time lost in each entrance direction. Then using TRRL signal timing optimization formula calculates the timing scheme.

2.2 Adaptive timing control

Fixed timing control adapts to the traffic condition that change regularly, so it has boundedness. When traffic condition change irregular, it will leads to an increase in the number of stops and delays. While adaptive timing control can measure the current road conditions continuously, it can change system parameters to make traffic control better in real time.

When using adaptive timing control, signal timing control software receives real-time traffic volume from simulation system by fixed time interval and makes timing scheme automatically. Considering stability, time interval must be longer than one signal cycle length and new timing scheme should be updated after the end of a signal cycle.

2.3 Signal timing control software operation

As show below, the figure 3 is human-computer interaction interface. According to guidance, it needs manual operation to accomplish signal timing control.

First, it needs to fill actual and saturated traffic volume, green interval and starting time lost of each entrance direction in operation interface. Then click the timing button to get timing scheme. Next, signal timing software sends timing parameters and time sequence to simulation system. By this way, timing software controls intersection simulation until it receives end signal from simulation system.

If it is adaptive control, signal timing software receives real-time traffic volume from simulation system by fixed time interval. And it calculates new timing parameter automatically. Then it executes new timing control scheme to adapt to traffic change.

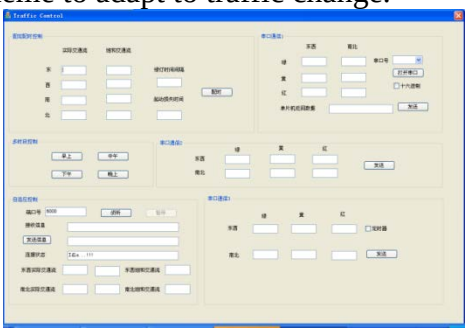


Figure 3. Signal timing control software operation interface

3. Intersection traffic simulation

Combined with timing control software, intersection traffic simulation using SUMO software has human-computer interaction interface. It simulates intersection traffic situation according to timing parameter receiving from timing control software. And it sends real-time traffic volume to timing control software when it is adaptive control. Finally simulation result data can be used to calculate traffic delay that is the key to evaluate the road service level. Simulation process is shown in figure 4.

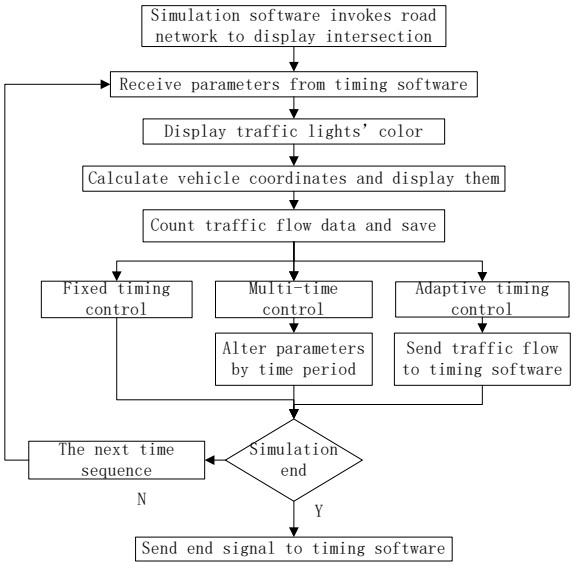


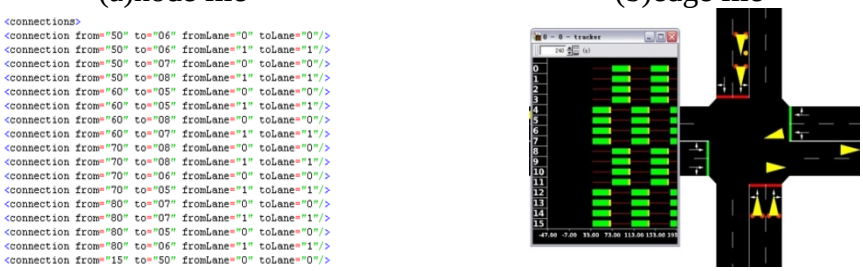
Figure 4. Simulation process

3.1 Realization of intersection traffic simulation

First of all, simulation needs to redact road network file. In this paper, the road network file is generated by point file, edge file and connection file, which uses NETCONVERT order. Then simulation needs to redact traffic flow file that is traffic demand. It mainly defines vehicle type and vehicle travel route, etc. In addition, simulation uses it to calculate time interval of vehicle interposition.

DUAROUTER order can combine traffic flow file with network file to generate route file. After redacting configuration file, the SUMO starts intersection simulation according to timing parameters in real time. It also can track traffic lights state. All of these files are structure by XML. Establishment and run of the simulation is shown in figure 5.

(a)node file (b)edge file



(c)connection file (d) Simulation run and traffic lights track

Figure 5. Establishment and run of the simulation

3.2 Analysis of simulation result

After end of simulation, there are three files outputted that respectively are vehroutes.xml, tripinfos.xml and emissions.xml. Vehroutes.xml is vehicle route file that includes serial number, type, start and end time and route of every vehicle, etc. Tripinfos.xml is journey information file that includes speed, travel length, time and position of every vehicle‘s start and end, etc. Emissions.xml is departure information that includes vehicle number of departure and end, average waiting time and travel time at every moment, etc. These fies includes a lot of valuable information.

Using travel time, travel length and vehicle number, the time required via intersection by average speed can be calculated. Therefore, traffic delay can be got by following formula:

$$t_{di} = t_i - \frac{nS_i}{\sum_{i=1}^{n} \frac{S_i}{t_i}}$$

In the above formula, t_{di} is traffic delay; t_i is travel time; S_i is travel length. According to average traffic delay, service level and capacity of the intersection can be assessed by HCM2000,which is used to optimize signal timing. By trial and error, optomal signal timing scheme will be found to improve road condition.

3.3 Verification of optimized results

In this section, we choose a plane intersection to verify the optimized results of the signal timing.

The traffic condition selected intersection as shown in table 1.

Table 1. The traffic characteristics table

Import	The actual traffic（pcu/h）			Saturated traffic（pcu/h）
	Left turn	Go straight	Right turn	
East	225	1278	203	3000
West	240	1224	265	3000
South	80	959	321	2000
North	91	934	301	2000

Through the analysis of simulation results with the two methods, we find the timing plan can be optimized to a certain extent. This analysis selected the sample size of 300. The results are shown in table 2.

Table 2. Traffic delays results contrast table

Indicator	Timing plan	Max（s）	Min（s）	Average（s）
Traffic delays	Original	61.28	3.28	37.28
	Optimized	54.57	2.57	29.57

In a summary, by the timing optimization, the traffic delay is reduced. It is obvious that the traffic capacity of roads is improved.

4. Summary

On the basis of traffic signal control theory, this paper designed single intersection signal timing control software. It can accomplish fixed timing control, multi-time control that timing control is handled separately in different time periods and real-time daptive control. Therefore, it can adapt to various timing requirements. Simulation designed by SUMO can response to the current road conditions intuitively. Combined timing control with simulation, this design is able to describe the actual traffic situation of the intersection. And it outputs detailed traffic flow information that can be used to analyze traffic delay and road capacity. This not only can do simulation research on a computer, but also can be applied to practice. The optimization result would help to easy the traffic pressure of urban intersection up.

References

[1] Guanghui Han, “Microscopic Traffic Simulation Study Based on SUMO Platform,” Computer Engineering and Science. 2012.

[2] Nakamiti, Gilberto, “Intelligent real-time traffic control,” International Journal of Smart Engineering System Design, v 4, n 1, p 49-62, January/March 2002.

[3] Alvarez, Israel , “Game theory applied to urban traffic control problem,” Lecture Notes in Computer Science, v 8025 LNCS, n PART 1, p 28-37, 2013.

[4] Khamis, Mohamed A. , “Adaptive traffic control system based on Bayesian probability interpretation,” Proceedings of the 2012 Japan-Egypt Conference on Electronics, Communications and Computers, JEC-ECC 2012, p 151-156, 2012.

[5] SUMO User Documentation. . 2011

[6] Suzuki, Tadamichi, “Analysis and modeling of practical experiment on IP traffic control,” Electronics and Communications in Japan, v 93, n 1, p 9-18, January 2010.