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Study on simulation method for intersection hybrid traffic flow

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Abstract: In hybrid traffic conditions at intersections, the speed of various transport modes is different and the traffic conflicts occur frequently, which lead to traffic chaos. Reasonable simulation method is very important for improving intersection state and capacity. The process and method of microscopic traffic simulation are studied, this paper considers the impacts of pedestrians and non-motorized vehicles, then designs a simulation process for intersection hybrid traffic flow. Taking an orthogonal intersection as an example, through data survey, problems analysis, optimization scheme design and simulation evaluation, the validity of the proposed method is verified.

Keywords: Traffic Engineering, Hybrid Traffic Flow, Microscopic Traffic Simulation, Intersection, Traffic Organization and Optimization

1. Introduction

As an effective mean and auxiliary tool of traffic planning and designing, microscopic traffic simulation has been widely applied in developed countries (Yang & Sun, 2010). However, the technology of simulating urban hybrid traffic flow is not mature in china. Accurate data collection and analysis and model validation are often neglected in traffic simulation, the model can't reflect the actual situations completely when mock the real system, which may influence the authenticity and reliability of simulation results (Sun, Yang, & Liu, 2007; Sun & Li, 2010). Urban road intersection is a complex system, if the simulation method is not reasonable, the efficiency and results will be difficult be guaranteed.

2. Simulation Process Design for Hybrid Traffic Flow

2.1. Process Design

This paper divides microscopic traffic simulation process into five parts: determination of simulation target, traffic data survey, traffic data analysis, simulation modeling, design and evaluation of optimization schemes. The simulation process is shown in Fig.1.

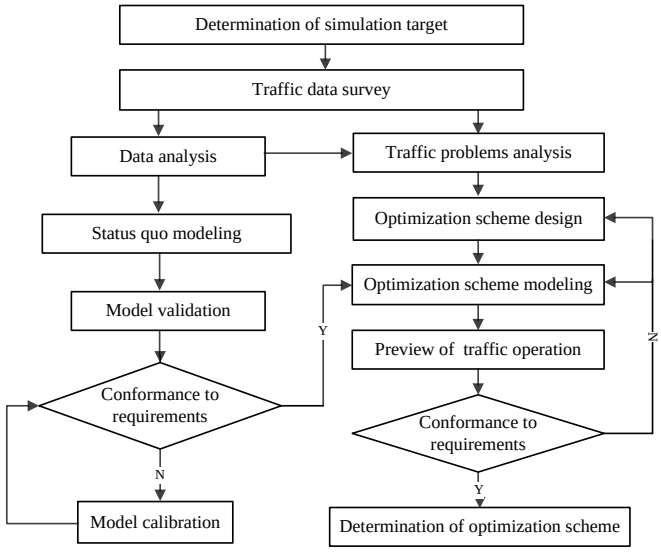

Fig. 1: Simulation process of hybrid traffic flow.

2.2. Traffic Data Survey and Analysis

As the foundation of model parameters calibration and traffic simulation, basic traffic data must be surveyed accurately and comprehensively, which directly affects the fidelity of models and the reliability of schemes evaluation (Wei, Yang, & Cao, 2003; Patlins, 2011). The collection traffic date mainly include static flow of the various traffic means, vehicle types, desired speed of different type vehicles, pedestrian and non-motorized vehicle flow, traffic management data, bus information and detailed geometric data, etc.

The traffic flow not only changes over time, but also with the spatial variation. By analyzing the spatial and temporal distribution and variation tendency of the traffic flow, we can determine the simulation period, meanwhile, the traffic demand change during the entire simulation period is reflected. Through the comprehensive analysis of traffic data, the major traffic problems of the intersection are determined, which provides the basis for designing optimization schemes.

2.3. Design and Evaluation of Optimization Schemes

On the basis of analyzing the principal contradiction, this paper optimizes the intersection from several aspects, including channelization, traffic organization optimization and signal timing. After the optimization schemes are designed, it is necessary to employ simulation software to test them, the final optimization schemes should be implemented conveniently and solve the traffic problems effectively.

There exist a certain degree of similarities among different intersections, for improving the efficiency of the program design, we should classify different kinds of traffic problems in accordance with certain characteristics, such as signal timing, violation and channelization, etc. According to the characteristics of different problems, we propose corresponding solutions and establish scheme library (Li, Rong, & Sun, 2009). This method can greatly improve the efficiency of optimization scheme design when optimize a large number of intersections.

3. Instance Application

3.1. Field Data Survey and Analysis

This paper takes Zhixinqiaoxia intersection as an instance, uses micro-simulation software VISSIM to analyze it, and then studies the validity of the method. Zhixinqiaoxia intersection is a signalized crossing, Fig.2 shows its geometric characteristics. The intersection adopts four-phase signal control program, the cycle length during peak hour is 180 seconds, Fig.3 shows the signal timing scheme.

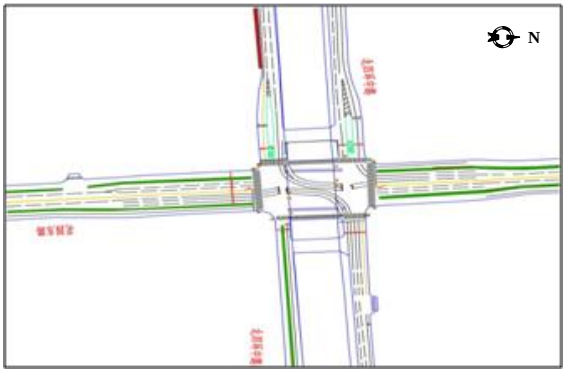

Fig. 2: Geometric diagram of Zhixinqiaoxia intersection.

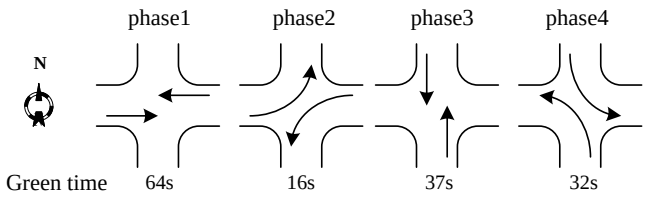

Fig. 3: Current situation signal timing scheme.

Selecting three working days and one weekend day of a week, this paper determines the peak hour by comparing the different period traffic flow, the results show that Tuesday morning 7:30-8:30 traffic flow is maximum, which is 6306pcu. The peak hour is the most critical period of traffic running in a day, it requires greater traffic capacity. Due to traffic flow of peak hour is very large, traffic problems are prominent particularly.

Pedestrian and bicycle analysis. The number of pedestrians and bicycles during peak hour is 1673 and 2528 respectively. The violation rate reach 6.7% and 7.1% particularly, which serious interfere the normal operation of motor vehicles.

Motor vehicle traffic analysis. As is revealed in Fig.4, straight flow of east entrance is maximum, which is the main flow. From the perspective of vehicle type, small vehicles account for the vast majority, mid-size vehicles and heavy vehicles account for a small percentage. Peak hour factor of the intersection is 0.91, which manifests that traffic flow changes small at different periods of peak hour.

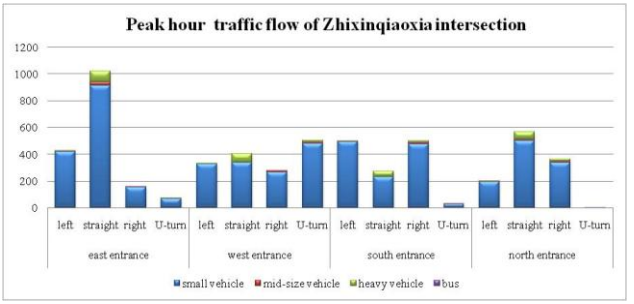

Fig. 4: Peak hour traffic flow diagram.

Comprehensive traffic problem analysis. Input lanes of east entrance and underground passage of west entrance are unreasonable. The main contradictions of the east entrance are saturation of straight lanes is too high and queue length is too long, however, the utilization rate of right-turn lane is low. West side of the intersection set an underground passage, the utilization rate of it is low, which peak hour pedestrian flow is only 60. Entrance and exit of the

underground passage are set between right-turn lane and straight lane, they take up the intersection area and badly influence the capacity of west entrance and lead to traffic congestion during rush hour.

3.2. Optimization Scheme Design

This paper takes traffic conflict, signal timing and channelization into consideration, designs a comprehensive optimization scheme. The program compresses the width of east entrance bicycle lane and moves it outside, adds a straight motor vehicle lane; moves the entrance and exit of the underground passage outside of bicycle lane, adds a left-turn lane. On the basis of above channelizing scheme, keep the signal cycle unchanged, adopt traffic signal timing optimization software SYNCHRO to optimize the split. The new signal control scheme is shown as Fig.5.

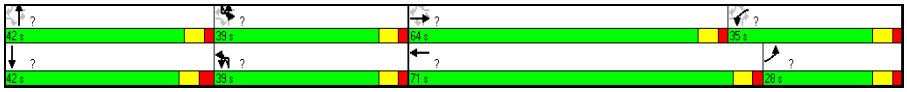

Fig. 5: The signal timing plan of split optimization.

3.3. Simulation Analysis

Current situation simulation. The mission of current situation simulation is to mock real traffic phenomena as much as possible, by comparing simulation data and field date, analyzes the authenticity of the simulation. The range of this simulation is intersection stop line back within 300 meters of road. Establishing the current model of intersection based on fundamental data, input the traffic volume, signal timing scheme and traffic operation parameters, etc.

Optimization scheme simulation and evaluation. Establishing the optimization scheme model based on the status quo model, testing the traffic operation condition and outputting the indicators. Using average queue size and average vehicle delay to evaluate the optimization scheme. The simulation results as illustrated in Fig. 6.

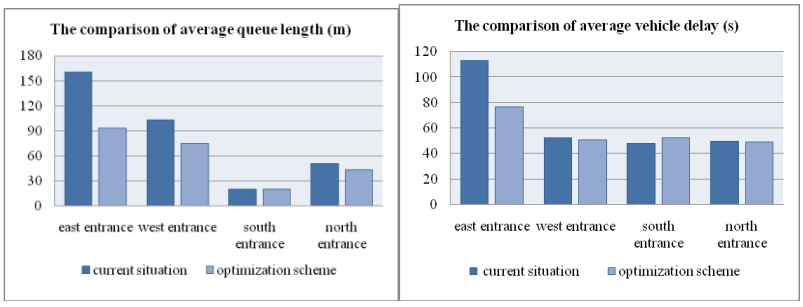

Fig. 6: The comparison of simulation results.

The overall average queue size and average vehicle delay of Zhixinqiaoxia intersection decreased by 21% and 12.8% respectively. Among them, the ameliorative effect of east entrance and west entrance are most obvious. The optimization scheme is feasible due to the intersection has channelization space.

4. Summary

This paper designs a simulation process for intersection hybrid traffic flow, and describes the specific method in detailed. Taking Zhixinqiaoxia intersection as an instance, a combinatorial optimization scheme is designed based on main traffic problems, employing VISSIM microscopic simulation software to simulate and analyze the optimization scheme, the results show that the method has practical value.

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