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Study of Intersection Optimization Near Transportation Hub Based on VISSIM

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Abstract

Traffic congestion is on the rise due to the continuing growth of urban areas, the increasing number of vehicles, and the increasing cost of building new roads. Therefore, it is necessary to explore creative and viable solutions to traffic problems at traffic intersections. On the basis of on-site traffic data collection, the traffic model was established，by taking both vehicle and pedestrian into consideration of intersection near Songjiang University Town Station transportation hub, using VISSIM. Simulation results showed that traffic congestion was higher in Meijiabang Rd (East to West) road section, which also had higher vehicle flow disorder and lane change pattern. Correspondently, intersection optimization were done in four aspects, including traffic signal green and red light timing adjusting, adding conflict area between straight and left-turn lanes, and road section movement. After optimization, traffic congestion was reduced in this intersection, which indicated the effectiveness of optimization on traffic management in this intersection.

***Keywords**: Intersection, simulation, optimization, VISSIM*

1. Introduction

Simulation is instead considered as a widely used technology in research, planning, demonstration and development of traffic systems [1]. Traffic simulation systems can be developed both at macroscopic and microscopic levels [2-3].

Microscopic traffic simulators, such as AIMSUM, PARAMICS and VISSIM, have been widely used as an analysis tool in transportation design as well as assessment [4]. The main modeling components of microscopic traffic simulation model are: accurate representation of the road network geometry, detailed modeling of individual vehicles behavior, and explicit reproduction of traffic control plans. The primary attention has been paid usually to the proper modeling and calibration of all these model components, namely the car-following, gap acceptance, lane change, and other internal models which along with other modeling parameters accounting for attributes of the physical system entities, allow the microscopic simulation model reproduce flow, speed, occupancies, travel time, average queue lengths, *etc.* with enough accuracy to consider the model valid.

There has been a good deal of research on road network analysis using microscopic software such as VISSIM both in theory and practice. VISSIM is traffic microscopic simulation software which has been widely used assessing traffic conditions. It is especially useful to evaluate different traffic management scenarios to choose the best alternative and optimization measures before implementation. Lin

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et al. (2013) built a road network model in VISSIM for Beijing CBD area, using travel time, travel speed, queue length and delay as evaluation indicators to conduct the comparison, thus to present the best option for traffic management in this area [5]. Qin and Xiong (2006) conducted one-way schemes simulation in VISSIM to evaluate traffic management in Kunming of China, and proved that VISSIM can offer some decision-making basis for the traffic management departments [6]. Li and Zheng (2011) described traffic characteristics used for the calibration of parameters for VISSIM, and analyze characteristics of traffic in Changsha, China [7]. Michael P. Hunter and Richard (2006) explore the ability to create an accurate estimation using real-time roadway data aggregated at various update intervals [8]. Muhammad and Robert (2009) provide a method for including pedestrians in VISSIM model. They define pedestrians as vehicles, and then calibrate various parameters in VISSIM so that pedestrian behavior is calibrated with pedestrian speed-flow models. Using a real traffic network with high pedestrian traffic crossing, their work demonstrates the feasibility of modeling vehicle-pedestrian interactions in a realistic manner [9].

2. Material and Methods

2.1. Site

The study site was located near Songjiang University Town transport hub. The intersection was between Jiasong Rd and Meijiabang Rd, which was just beside the rail transit station Songjiang University Town in Line 9, shown in Figure 1. This intersection was one of the main intersections for the Songjiang University Town transport hub.

It was a combination of rail transit, bus and private car exchanging mode. In this transport hub, there were 3 bus stations, with 16 bus lines. All the bus lines went through South Jiasong Rd and Meijiabang Rd. And there were also 4 resident parking lots, located in the northwest and southwest corner of the intersection.

2.2. Method

Traffic simulation or the simulation of transportation systems is mathematical modeling of transportation systems through the application of computer software to better help plan, design and operate transportation systems [1]. In this case, PTV VISSIM was utilized. PTV VISSIM is a microscopic multi-modal traffic flow simulation software package developed by PTV Planning Transport Verkehr AGin Karlsruhe, Germany. In VISSIM, each entity (car, train, persons) of reality that is to be simulated is simulated individually, *i.e.* it is represented by a corresponding entity in the simulation, thereby considering all relevant properties. The same holds for the interactions between entities [2-10]. Its application ranges from various issues of traffic engineering (transport engineering and planning, signal timing) and public transport.

2.3. Model Establishment

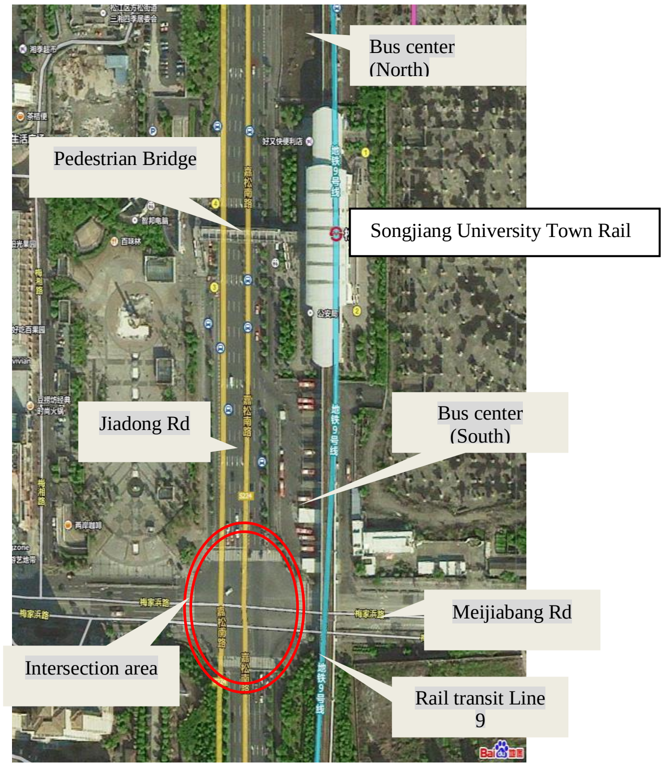

Figure 1. Site Location and Distribution Scheme

To establish simulation model of road system, the real status plane graph with measuring scale should be imported first. The plane graph was screenshot from Baidu Map, shown in Figure 2. Based on the plane graph, the road section of Jiasong Rd (8 lanes in two ways) and Meijiabang Rd (6 lanes in two ways) was established by Link module, and then collected to form the basic road net. The road was defined as downtown motorized road, with 3.5m width. The established road net model was shown in Figure 3.

Figure 2. Screenshot of Intersection

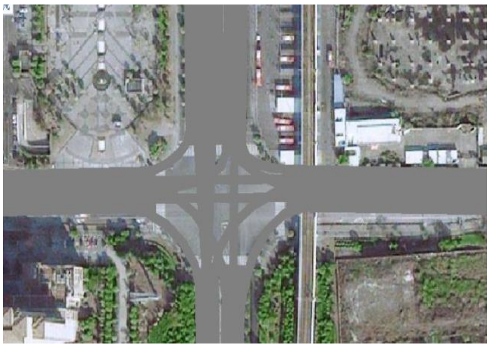

Figure 3. Established Road Net Model

According to traffic regulation, passing priority guideline was set using the conflict area function module in VISSIM. The conflict area [10] setup was shown in Figure 4.

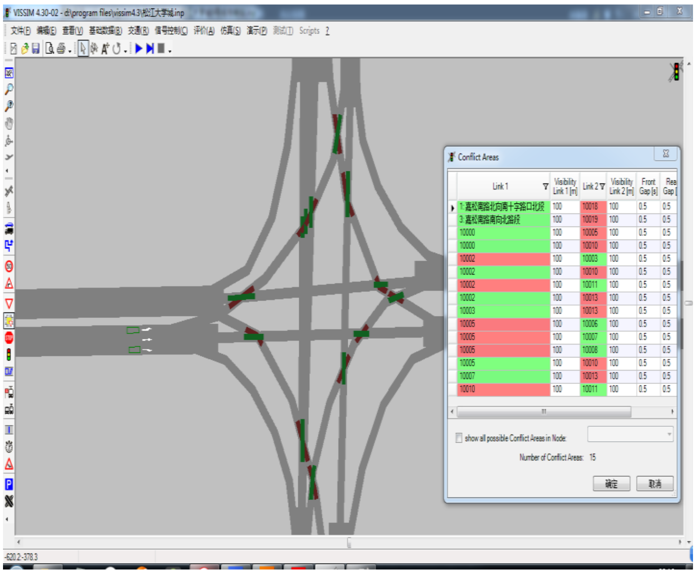

Figure 4. Conflict Area Setup

In each road section, the stop mark line was set with speed limit zone 30m before the stop line. The speed limit was 60km/h. Slow down area was also set in turning lanes, with 25km/h. The stop line scheme was shown in Figure 5.

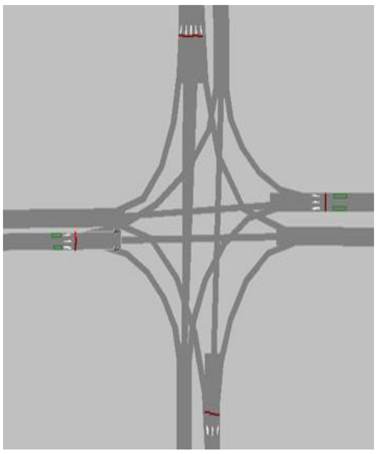

Figure 5. Stop Line Arrangement

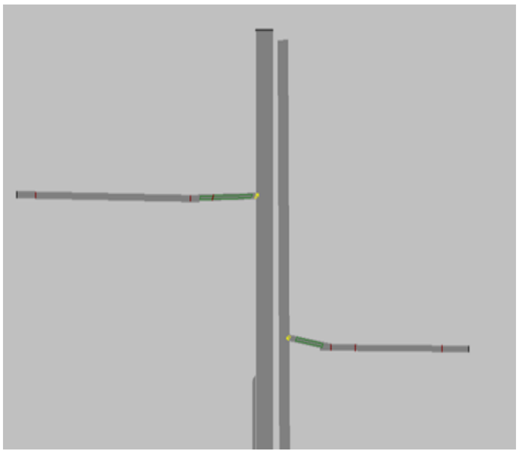

Figure 6. Pedestrian's Bridge Transfer Model

In this case, railway Line 9 was also considered to be an input for the whole system. Thus, the passenger flow from the pedestrian bridge was transferred into vehicle flow to simulate passenger transfer. Two single lane roads were established and collected to the both sides of Jiasong Rd, with stop line at connecting area, shown in Figure 6.

Three signal controls were established in signal control module, which controlled signal in Jiasong Rd, Meijiabang Rd, and pedestrian bridge. There were allocated at the stop lines.

3. Data Collection

3.1. Data Collection

The data was collected in the intersection from 8 am to 10 am in working day. Vehicle flow, passenger flow, traffic signal timing, travel timing, delay timing and queuing length [11] were collected through on-site observation.

3.2. Vehicle Flow

Vehicle flow was obtained through counting the passing vehicle amount during 8 am to 10 am in 5 minute interval in the four sections of in this intersection. The mean value was shown in Table 1.

Table 1. Vehicle Flow in Four Sections

Road	Direction	Vehicle flow (/h)
Jiasong Rd	North to South (N to S)	1104
Jiasong Rd	South to North (S to N)	780
Meijiabang Rd	East to West (E to W)	240
Meijiabang Rd	West to East (W to E)	528

Vehicle flow was obtained through counting the passing vehicle amount during 8 am to 10 am in 5 minute interval in the four sections of in this intersection. The mean value was shown in Table 1.

3.3. Traffic Signal Timing

Traffic signal timing was obtained from recorded signal data in one week in 8 am to 10 am in working days. The signal timing of four road sections was shown in Table 2.

Table 2. Signal Timing for Four Sections

Section	Direction	Straight lane		Left turn	
		Green	Red	Green	Red
Jiasong Rd	N to S	50s	61s	15s	96s
Jiasong Rd	S to N	50s	61s	15s	96s
Meijiabang Rd	E to W	40s	71s	40s	71s
Meijiabang Rd	W to E	40s	71s	40s	71s

The signal timing in pedestrian bridge was matched with railway Line 9 timing. Generally, the arriving interval for Line 9 in Songjiang University Town station was 5 minutes in morning peaking period. In other words, the traffic flow change interval should be 300 seconds. Thus the red light signal control in pedestrian bridge to Jiasong Rd interval was set to 300 seconds. For passenger, it will take less than 60s to walk through the pedestrian bridges. So, the green light signal time was 60s, to ensure complete passenger flow output.

3.4. Passenger Flow

Passenger flow was gained by counting the amount of passenger went through the pedestrian bridge to both side of Jiasong Rd in setting time period after each rail transit arrived. The data was also collected during morning peak time 8 am to 10 am, shown in Table 3.

The main passenger flow was from railway Line 9. And most of the passenger went on bus to join the vehicle flow. Therefore, the passenger flow should be transferred to vehicle flow. A standard bus with recommended 28 passengers was utilized to calculating the corresponding vehicle flow from pedestrian bridge to Jiasong Rd. The corresponding vehicle flow was shown in Table 4.

Table 3. Passenger Flow through Pedestrian Bridge (/min)

	N to S exit to Jiasong Rd	S to N exit to Jiasong Rd
1	65	28
2	52	37
3	55	31
4	61	34
5	59	33
Average	58.4	32.6

Table 4. Vehicle Flow from Pedestrian Bridges to Jiasong Rd

Road section	Corresponding vehicle flow (/h)
N to S exit to Jiasong Rd	25
S to N exit to Jiasong Rd	14

4. Simulation and Analysis

Simulation was conducted in VISSIM to evaluate the traffic condition in the intersection. Generally, the vehicle flow in this intersection was quite disordered. Travel conflict was observed between straight lane and left turn lane, shown in Figure 7 and Figure 8. And the frequent changing lane for driver due to unmatched timing signal reduced the traffic flow smoothness.

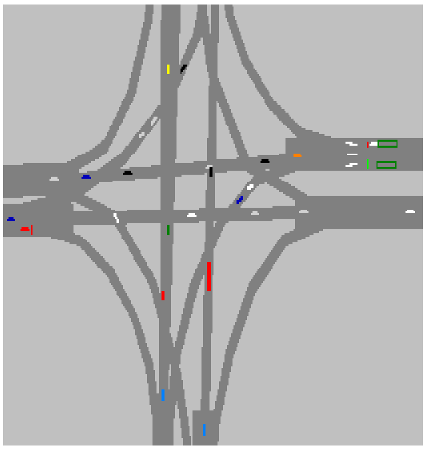

Figure 7. Traffic Disorder Travel

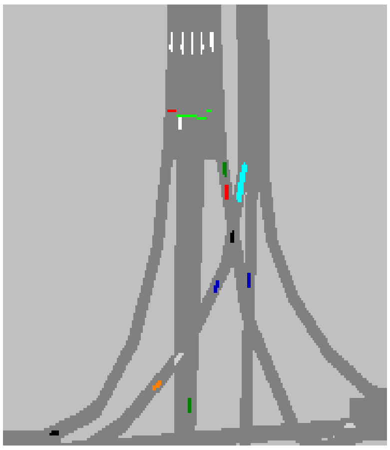

Figure 8. Traffic Congestion in Turning Lanes

To quantified understand the traffic condition of this intersection, travel time, queue length and delay time were used in simulation. Queue length, travel time and delay time data were shown in Table 5, 6 and 7.

Table 5. Queue Length for Four Road Sections

Section	Direction	Queue length/m		Stops
		Mean	Max	
Jiasong Rd	N to S	1	31	2
Jiasong Rd	S to N	1	31	8
Meijiabang Rd	E to W	3	39	21
Meijiabang Rd	W to E	16	49	38

Among the four road sections, Meijiabang (W to E) had the highest queue length, travel time and delay time, which had the biggest impact on the traffic travel in this intersection.

Table 6. Travel Time for Four Road Sections

Section	Direction	Simulation time/s	Travel time/s	Vehicles
Jiasong Rd	N to S	1200s	58.3	144
Jiasong Rd	S to N	1200s	58.6	78
Meijiabang Rd	E to W	1200s	63.1	76
Meijiabang Rd	W to E	1200s	69	63

Table 7. Delay Time for Four Road Sections

Road section	Direction	Delay time/s	Stops	Vehicles
Jiasong Rd	N to S	1.1	2	144
Jiasong Rd	S to N	1	8	78
Meijiabang Rd	E to W	2.3	21	76
Meijiabang Rd	W to E	7.9	38	63

5. Optimization and Analysis

5.1. Optimization

Based on the simulation results, optimization was done accordingly.

For Meijiabang Rd (W to E) section, the straight lane light signal was modified, with green time increased from 40s to 50s and red time reduced from 71s to 61s. And the left turn light was also changed, with green time increased from 15s to 30s, red time reduced from 96s to 81s.

Added extra conflict area was put between all the lanes in Meijiabang Rd (W to E) section and the straight and left turn lanes of Jiasong Rd, thus to reduce the vehicle stop time in Meijiabang Rd (W to E) section to yield vehicle from Jiasong Rd, shown in Figure 9.

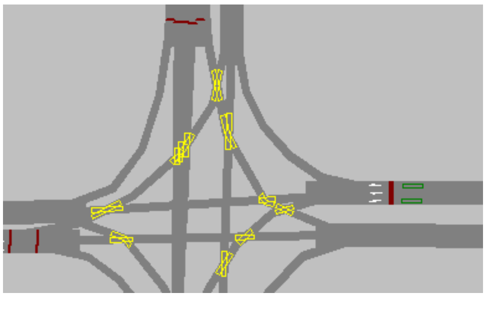

Figure 9. Added Conflict Area

Besides, the stop lines in all the four sections were moved 5m further away from the initial lines, to reduce the possibility of traffic congestion due to lane changing from drivers.

5.2. Simulation Results

After optimization, the traffic flow in the section was smoother, with less interference among lanes and stop in lanes, shown in Figure 10. The indicator of queue length, travel time and delay time of Meijiabang Rd was reduced to normal condition, shown in Table 8, 9 and 10. And the total passing vehicle amount increased slightly in this intersection. Besides, the lane change activity close to the stop lines in four road sections was reduced obviously. The results indicated the effectiveness of optimization on traffic management in this intersection.

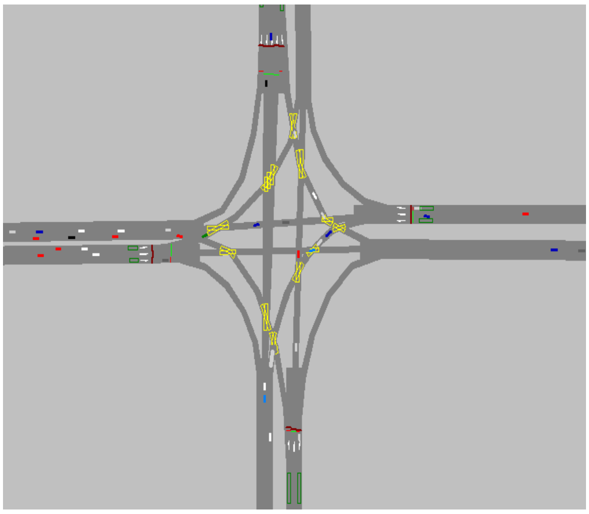

Figure 10. Traffic Flow in the Intersection after Optimization

Table 8. Queue Length for Four Road Sections after Optimization

Road section	Mean queue length/m	Max queue length/m	Stop amount
Jiasong Rd (N to S)	1	31	3
Jiasong Rd (S to N)	1	31	7
Meijiabang Rd (E to W)	2	33	12
Meijiabang Rd (W to E)	2	29	8

Table 9. Travel Time for Four Road Sections after Optimization

Road section	Simulation time/s	Travel time/s	Vehicle amount
Jiasong Rd (N to S)	1200s	60.2	142
Jiasong Rd (S to N)	1200s	61.7	81
Meijiabang Rd (E to W)	1200s	59.2	77
Meijiabang Rd (W to E)	1200s	58	65

Table 10. Delay Time for Four Road Sections after Optimization

Road section	Delay time/s	Stop amount	Vehicle amount
Jiasong Rd (N to S)	1.1	5	142
Jiasong Rd (S to N)	1.1	8	81
Meijiabang Rd (E to W)	1.3	11	77
Meijiabang Rd (W to E)	1.3	9	65

6. Conclusions

On the basis of on-site traffic data collection, the traffic model was established taking both vehicle and pedestrian into consideration of intersection near Songjiang University Town Station transportation hub, using VISSIM. Simulation results showed that traffic congestion was higher in Meijiabang Rd (East to West) road section, and also had higher vehicle flow disorder and lane change pattern. Correspondently, intersection optimization were done, including traffic signal green and red light timing adjusting, adding conflict area between straight and left-turn lanes, and road section movement. After optimization, the traffic congestion was reduced in this intersection, which indicated the effectiveness of optimization on traffic management in this intersection.

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