Simulation Platform oriented to Traffic Control and Guidance Coordination System

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Abstract-**Urban traffic control and guidance coordination system is an important part of Intelligent Transportation System. Aiming at testing and validating problems of traffic control and guidance coordination system in laboratory, this paper mainly discusses the design and development of simulation platform oriented to traffic control and guidance coordination system as well as the mechanism of on-line operations between virtual and real systems. The foundation is provided for the algorithm and equipments of system by establishing a virtual simulation platform, which can co-exist with real traffic control and guidance coordination system.**

Keywords- **Simulation platform, control system, guidance system**

I.INTRODUCTION

The urban traffic on-line management of Intelligent Transportation System is realized by traffic control and guidance coordination system which consists of traffic control system, traffic guidance system and traffic coordination system.

Traffic control system, mostly based on signal lights in intersections, takes charge of the passing time of each direction on the road in order to eliminate the congestion of traffic network. It can be usually divided by space into single-point control, line control and regional control, and by control principle into timing control, inductive control and adaptive control and so on.

Traffic guidance system is operated on the guidance equipments on the road to give the drivers route suggestion and achieve the space equilibrium in traffic network. Since it was put forward in the 80s of last century, some results have been made, such as guidance system based on forecasting[1]-[3] and responding[4]-[6].

Traffic control system controlling traffic flow from time domain and traffic guidance system adjusting traffic flow from space domain are not isolated but related[7]. For the correlativity, traffic coordination system should be constructed to take the two systems into account to avoid the conflict between control strategy and guidance strategy and manage the traffic system at higher level. Papers [8]-[10] give some models and algorithms.

After the establishment of traffic control and guidance system in labs, operating test of each system as well as verification of the optimized methods are essential. Because both traffic control system and traffic guidance systems are confronted to the whole urban traffic network, the construction of equipments on a massive scale will be costly and highly risky. All of these are not allowed in test stage and unavailable in labs. Therefore, a simulation platform oriented to traffic controls and guidance coordination system, which can simulate and test the real traffic control, guidance and coordination system in labs, is indispensable. The simulation platform will provide the foundation of system developing and testing. The experimental cost will be reduced and the success rate of system construction will be promoted. For this purpose, the development and design of simulation platform oriented to traffic control and guidance coordination system and the real-time operating mechanism of multi-system are discussed in this paper.

II.TRAFFIC CONTROL AND GUIDANCE COORDINATION SYSTEM AND SIMULATION PLATFORM

Traffic control and guidance coordination system consists of detectors in charge of data collection in transportation network; signal lights and their controllers in charge of the order of vehicle entering intersections and colors displayed in signal lights; guidance display located in the road released the route guidance for the passing vehicle; control system, guidance system, coordination system and information platform provided management for the whole traffic system.

The simulation platform, comparably, has not only the ability of simulating vehicles, road section and intersections, but also can simulate traffic control and guidance equipments. Meanwhile, this system should have the on-line work ability with traffic control system, traffic guidance system and traffic coordination system in reality world via the computer network, so we can accomplish testing of system algorithm and performance.

Different from urban traffic flow simulation integrated control and guidance algorithm, simulation platform oriented to traffic control and guidance coordination system should has the following differences or characteristics:

1) Simulation purpose is different. Obtaining the response of traffic flow to control and guidance strategies is the common simulation purpose. Moreover, the simulation platform can not only validate the effect of traffic control and guidance strategies, but also test the working conditions and design principles, etc.

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2) Simulation objects are different. The simulation platform should provide the simulation of both vehicle, road, intersection and the real traffic control and guidance equipments. Moreover, this simulation is not only on the equipment functions, but also working principles.

3) Simulation mechanism is different. Co-existence of real and virtual system in the real-time online environment is one of remarkable characteristics. The virtual simulation platform and the real traffic control system, guidance system, coordination system on-line operate simultaneously for testing the real system.

4) Simulation environment is different. Different simulation purpose, object, mechanism determine the different simulation environment—Local Area Network (LAN). Multiple systems compose of a small-scale LAN taken communication protocol as the data transmission. Real and virtual systems cooperative work in the LAN.

III.HIERARCHY AND SYSTEM STRUCTURE OF SIMULATION PLATFORM

A. Hierarchy Structure of Simulation Platform

As the real-time testing platform of traffic control, guidance and coordination system, the simulation platform oriented to traffic control and guidance coordination system is different from the common traffic flow simulation system with control and guidance algorithm. The platform should have the parallel status or relationship with other systems running in the real urban traffic network. Each system is connected by communication equipments and operates independently. Simulation platform receives the control and guidance strategies, and sends the real-time traffic flow data collected by the virtual traffic flow detectors to relevant systems. The relationship and structure among these systems is showed in Fig 1.

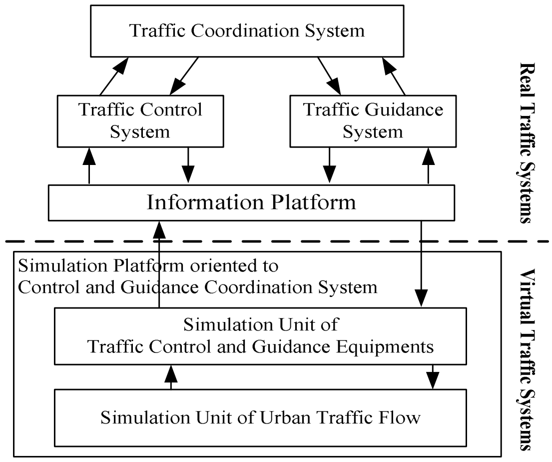

Fig. 1. Hierarchy structure of simulation

Urban traffic flow simulation unit is the simulation to vehicles and traffic network; control and guidance equipments simulation unit focuses on the simulation to the function and working modes of real traffic control and guidance equipments. The simulation platform oriented to the control and guidance coordination system is comprised by both urban traffic flow simulation and control and guidance equipments simulation. Control and guidance equipments simulation is the bridge connected the reality and virtuality, and makes it possible to cooperative work on line between reality and virtuality.

B. System Structure of Simulation Platform

The simulation platform oriented to traffic control and guidance coordination system consists of vehicle driving models, initialization models, human-computer interaction models and data base system (Fig 2).

Traffic network, vehicles and control and guidance equipments are generated, and all kinds of physics and geometry parameters, which is the necessary external parameters of simulation kernel are assigned in initialization models.

Simulation kernel, which consists of vehicle driving models and control and guidance equipments, takes charge of vehicle's driving rules in road and intersection, as well as detector's detecting to traffic flow, signal lights' display and

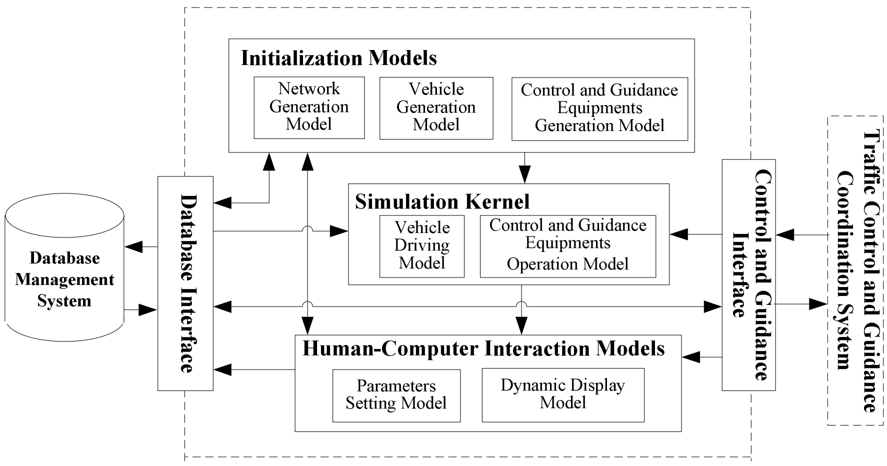

Fig. 2. System structure of simulation platform

guidance panels' information releasing, etc.

IV.OBJECT MODELS OF SIMULATION PLATFORM

As the abstract and reproduction of real world in the computer, based on the analysis of traffic system, a completed simulation platform oriented to control and guidance coordination system should involve the following entities: road, line, intersection, signal lights, guidance information display, buses, trucks, cars, risk-love driver, risk-medium driver, risk-hate driver, etc.

After the optimizing the above entities, the classes are given as follows:

C. The simulation of traffic control and guidance system

1) Class Detector (CDetector). Traffic flow detector, which is set in specified line position, calculates the total number of passing vehicles. CDetector should have the ability of counting the average vehicle number and average vehicle speed in time unit.

2) Class Guidance Information Display (CGuidance). Guidance information shows the crowd degrees of forward roads and is the tool of information publication. CGuidance receives the guidance strategy and releases the guidance information to the CVehicle passed it.

3) Class Signal Light (CLight). The main function of CLight corresponding to the intersection is changing the color of lights according to the timing plan, i.e. calculating the current light color by some control parameters such as phase circle, phase difference, green ratio, etc.

4) Class Signal Lights Controller (CController). CController corresponding to the intersection controls the lights in the intersection. According to the requirement of control system and equipments at present, the main function of CController should includes: receiving regional control strategy, calculating the single-point control strategy by traffic flow data getting from neighboring detectors, modifying and transmitting the timing plans according to control strategy, etc.

D. The simulation of urban traffic flow

1) Class Link (Clink). A road is divided into two links by allowed driving direction, and the ending point of each link is corresponding to the other's starting point. The directed graph composed of links is as traffic network in the simulation.

2) Class Line (CLine). Link is composed of lines, in which vehicles run. Three types of line are divided by different turns: left turn line, right turn line and straight turn line. Class line-in-intersection (CIntersectionLine), which is the path of vehicle driving in intersection, inherits Cline.

3) Class Intersection (CIntersection). CIntersection mainly includes the array of confliction points and the properties described the shape of intersection.

4) Class Vehicle (CVehicle). Driving rules, such as car-following, free driving, overtaking, changing line, as well as driving in the intersection with confliction points, are included in CVehicle. By the inheritance, diversified types of vehicles can derive from CVehicle.

Others classes, such as Class Driver (CDriver), Class Orientation (COrientation), Class Confliction (CConfliction), Class Communication (CCommunicator), etc, will not be explained in detail.

V.DYNAMIC MODELS OF SIMULATION PLATFORM

As an important link to coding, dynamic models describe the dynamic relationship among the objects, and usually include globe events chart and state diagram.

Parts of global events in simulation platform are shown in TABLE I.

The objects with dynamic characteristics are CVehicle, CLight, CController, CGuidance, COrientation, CDestination, etc. The dynamic characteristics of others objects are the responses to the one of above objects, i.e. the function of above objects. Due to the limited space, only the states of signal lights controller and vehicle running in road are given in Fig 3 and 4 respectively. Signal lights controller is to generate timing plans and send them to relevant lights, and car driving in road, which is the most complex state

TABLE I

GLOBAL EVENTS OF SIMULATION PLATFORM

Events	**Event Generator**	**Event Receiver**	**Event Parameters**
Vehicle Drives in Line	CVehicle;CLine	CLine	Generate Vehicle Object
Vehicle Accelerates (Decelerates)	CVehicle	Vehicle in front (back)	Acceleration (Deceleration)
Changing Line	CVehicle	Objective line; Vehicle in back of objective line	Vehicle position; Speed; Acceleration(Deceleration)
Pass Detector	CVehicle	CDetector	Vehicle Type and Speed
Send Guidance Strategy	CCommunicator	CGuidance	Link Number; Guidance Strategy
Send Control Strategy	CCommunicator	CController	Intersection Number; Control Strategy
Send Timing Plan	CController	CLight	Link Number; Timing Plan
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diagram, can be divided into four types of state, which are free driving, car-following, change line and overtake.

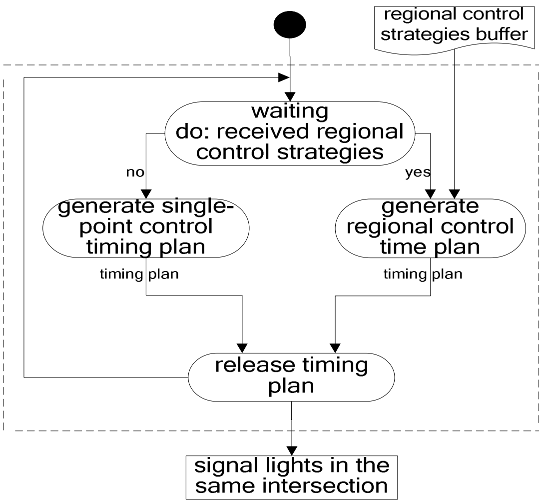

Fig. 3 Dynamic model of signal lights controller

experiments under multi-system coordinative on-line work of control system, guidance system, coordination system with simulation platform as the center and network communication as data transmission, aiming to test the algorithm and performance of real system.

Giving a comprehensive consideration of communication requirement of all systems and the service quality of LAN, UDP can be adopted as the communication method. Simulation platform is started at first, then other systems when the traffic flow tends to stability. Simulation platform transmits traffic flow data detected by virtual detectors to information platform, by which, control and guidance system obtain the necessary information and generate strategies respectively. After the optimization of coordination system, the control and guidance strategies will be release to the simulated traffic network by simulated equipments via information platform. After periodical circulation, the actual operation condition of all systems can be tested by such methods as the comparison of the traffic flow under supervision and non-supervision, in order to achieve the goal of testing the real systems and equipments through virtual simulation.

When virtual system and real system co-exist, however,

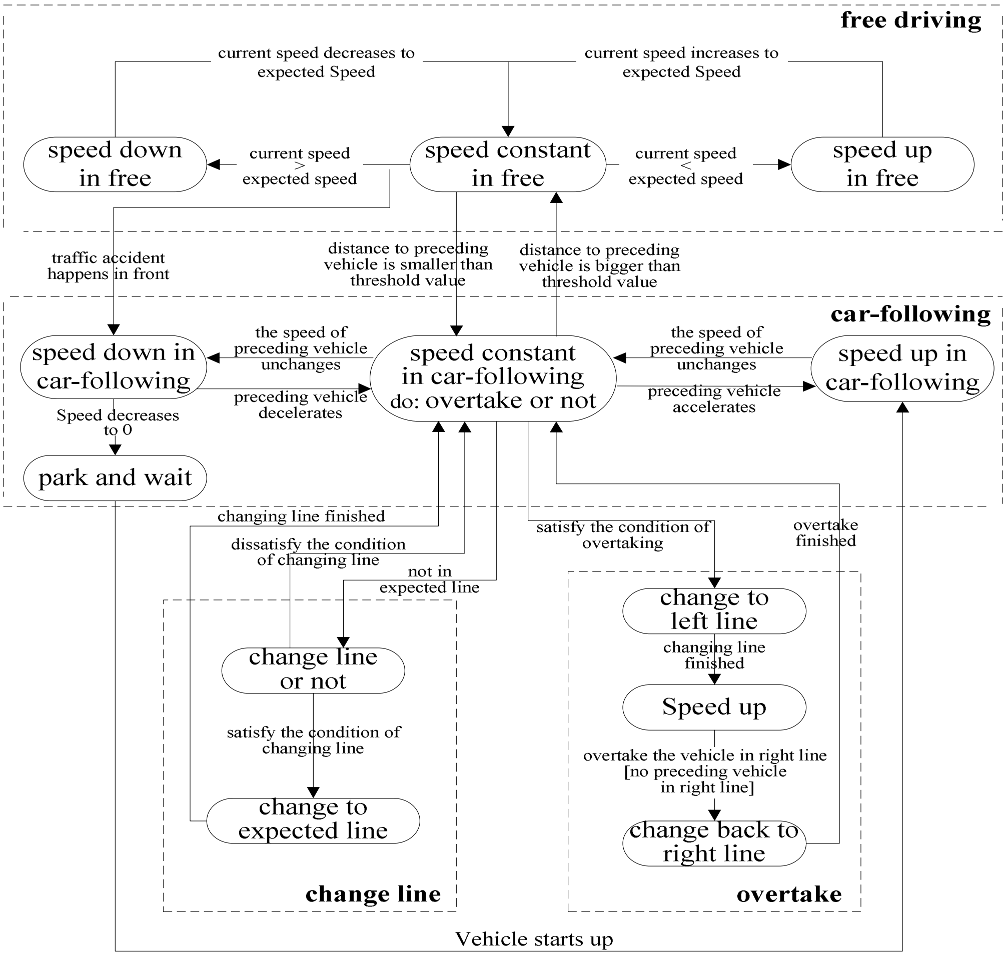

Fig. 4. Dynamic model of vehicle running in road

VI.ON-LINE OPERATIONS BETWEEN SIMULATION AND REAL TRAFFIC SYSTEMS

With the establishment of control and guidance coordination simulation platform, we can conduct the essential differences in working principles between traffic control and guidance coordination system in real world and simulation platform in virtual world will lead to a discrepancy between physical time (real time) of the former and logical time (simulation time) of the latter, which influence greatly on the performance of the whole systems. Take guidance system as an example, the guidance cycle normally is 5 min, and the generation of guidance strategy is

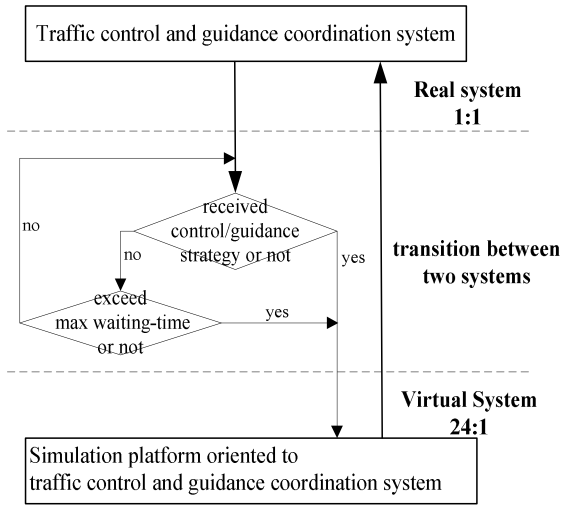

Fig 5. On-line operations between real and simulation systems

a searching process, which costs a few seconds (it's quite shorter than the real guidance cycle). Moreover, the different condition also determines the different generation time for strategy in each period. However, as the abstract of real world, simulation platform need make compression of physical time. Provided calculated by 60:1, the logical time of 5 sec in simulation will equal to 5 min in real world. The simulation "compresses" the traffic flow time. However, since the calculation of guidance strategy in guidance system is independent of simulation, it will lead to the contradiction in the time between the real and virtual systems.

In order to solve this problem, it is feasible to improve the simulation platform by properly extending step length of simulation and adding a "block" function to simulation platform. Extending step length means to reduce simulation speed. Usually, the simulation speed is high, and it will not affect the simulation effect and users' feeling to slow the speed down properly. For instance, if 24:1 is taken as the ratio of physical vs logical time (the simulating to the traffic flow of one day will be finished within 1 hour), the actual simulation cycle, such as 5 min, will correspondingly be 1.25sec. This time could basically meet the requirement of the generation of guidance strategy and will not affect users much. In order to avoid the longer delay in generation of guidance strategy, "block" function can be added, which means to register a network event of receiving the strategy in simulation. Only if the event is triggered, the simulation can continue, or else, it would be waiting and result in whole system waiting. This "block" function guarantee that the strategy will not be lost for any reason. If lower the standard, waiting time can be set. If the waiting time exceeds, the system will abandon this strategy and rerun automatically. This will avoid the long time delay caused by one strategy generating slowly (Fig 5).

VII.CONCLUSION

A set of simulation platform which can provide the testing and validating for the development of traffic control and guidance coordination system is indispensable to the construction of real system. This paper, starting from the analysis of real traffic control and guidance coordination system, studies the hierarchy and system structure which is necessary to simulation developing. The object models, such as class vehicle, class detector, etc, are given in the following, and the dynamic models of simulation are analyzed and designed. At last, the operating mechanism of real traffic control and guidance coordination system and virtual simulation platform are discussed. The strong foundation of simulation software developing is laid.

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