Intelligent Computing Technology and Automation
Z. Hou (Ed.)

doi:10.3233/ATDE231170

Modeling and Simulation of Intelligent Vehicle Flow Guidance Based on Agent

Huiyu XIE[1], Xin HU, Wenyuan WEI, Mian DAI, Xiyue ZHANG
China Automotive Technology and Research Center Co., Ltd; Automotive Data of China (Tianjin) Co., Ltd.,Tianjin, 300393, China

Abstract. In order to meet the needs of large-scale traffic control and traffic flow guidance coordination under the background of urban expansion, a regional traffic flow coordination control scheme is proposed by using agent and fuzzy control method. Firstly, the basic structure of Agent in intelligent traffic control is analyzed, and on this basis, an intelligent decision support system model for traffic flow prediction is established. Then, aiming at the shortcomings of agent in micro traffic simulation, it is proposed to combine other cellular automata for modeling. The fuzzy control strategy is applied to design the coordination controller for the execution strategy of the decision-making unit. The simulation results in MATLAB environment prove the effectiveness of the intelligent vehicle flow coordination control model, which can carefully describe the characteristics of traffic flow and the micro behavior of traffic entities.

Keywords. vehicle flow; Agent; CA; fuzzy control; MATLAB

1. Introduction

Predictive traffic flow adjustment through traffic flow prediction can ensure the reasonable distribution of traffic flow in the road network, realize the optimal allocation of transportation resources, and eliminate the backlog and congestion of traffic flow in time. The existing traffic flow prediction methods rely on manual experience and budget estimation. There are many problems in accuracy and hierarchy, which are far from meeting the needs of the development of railway modernization [1]. Therefore, the establishment of intelligent traffic flow prediction theory and the development of intelligent decision support system for traffic flow prediction have become the inevitable trend of the development of transportation scheduling command. Dynamic traffic flow guidance is an important subsystem of intelligent transportation system. It uses advanced technology in related science to calculate the optimal route according to the starting point and end point of travel, and through the analysis of real-time and historical traffic data, and provides other relevant traffic information to the driver, such as segment traffic flow, segment traffic saturation, etc. Traffic guidance system has developed from static traffic guidance to dynamic traffic guidance, which can use historical database and real-time traffic information for traffic guidance. Compared with traditional methods, such as coils, monitoring and acquisition equipment, this research model has the advantages of low cost, easy replication, high availability and so on [2]

[1] Corresponding Author: Huiyu Xie; China Automotive Technology and Research Center Co., Ltd; Automotive Data of China (Tianjin) Co., Ltd.,Tianjin,300393, China; xiehuiyu@catarc.ac.cn

Firstly, this paper analyzes the advantages and disadvantages of multi-agent system and cellular automata in the application of traffic simulation, and the feasibility of their combination in traffic simulation On this basis, this paper proposes an intelligent vehicle flow guidance model based on hybrid algorithm, and combines the actual data of a regional traffic simulation analysis. In the design of the coordination controller, the corresponding fuzzy control rules are established to assist the decision-making of important intersections. The simulation results show that the new traffic simulation modeling method proposed in this paper can accurately describe the characteristics of traffic flow, and it has better time efficiency.

2. Intelligent Transportation Technology Based on Agent

2.1 Intelligent Traffic Control

The transportation system itself is a complex system. According to the viewpoint of system theory, the internal activities of the system should be coordinated, so as to prevent focusing on the realization of the goal of a subsystem and ignoring the optimization of the whole system, and minimize the internal friction of the system as far as possible. In the coordinated control of road traffic system, the overall traffic system should be organized, coordinated and optimized from a high level, and a unified model should be established and applied to the actual control to achieve the optimization of road traffic system. Therefore, some scholars have proposed a conceptual model of traffic control system with hierarchical structure with agent as the control unit [3]. For the learning function of agent in traffic control, some scholars proposed to introduce the multi-agent method based on recursive modeling and Bayesian learning into urban traffic control. Combining these two methods, we can adjust our beliefs about other agents online according to the actual observed behavior changes

2.2 Agent Structure of Vehicle Driving

Driving behavior can be divided into three levels: strategic level, tactical level and operational level in terms of time scale and decision complexity. The strategic level deals with travel related issues, such as destination selection, travel mode, route organization, and so on. The tactical level classifies the traffic scenarios according to the perceived road traffic environment, and selects driving tasks, such as accelerating, decelerating, changing lanes, etc. The operation layer controls the accelerator, brake and steering angle according to the selected task to achieve the desired purpose. The driver agent structure is shown in figure 1.

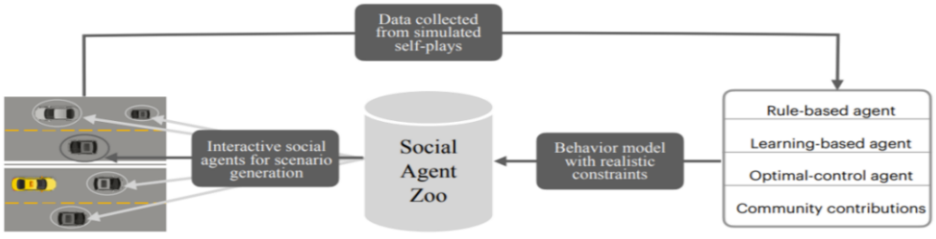

Figure 1. Wavelet denoising flow chart based on Bayes

In order to achieve the overall goal assigned by the strategic level, a basic operation is selected according to the perceived road and traffic conditions. Then the operation layer controls the vehicle according to the operation selected by the tactical layer [4]. The purpose of this paper is to achieve a traffic flow model that is computationally efficient and can reproduce the real micro and macro characteristics, so only the tactical level and the operation level are studied.

3. Agent based Intelligent Vehicle Flow Guidance Model

3.1 Agent Based Collaborative Framework of Traffic Control and Traffic Flow Guidance

According to the idea of hierarchical coordinated control of large-scale systems, the system is decomposed and hierarchical control is implemented [5]. The construction idea is described follows: the lowest level is the intersection agent, which is mainly responsible for obtaining real-time traffic data through the detector, optimizing and adjusting the intersection signal timing scheme according to the collaborative strategy, and transmitting the intersection traffic information and implementation results to the sub area agent. The second layer is the sub area agent, which is mainly responsible for controlling one or more intersection agents and coordinating with adjacent sub area agents. The third layer is the area control subsystem, which includes two types of agents. One agent is the area control agent. One of its functions is to coordinate and command the sub area agents in the area, and collect and analyze the traffic status of the sub area under its jurisdiction; The second function is to judge the traffic status in the region according to the collected information of the regional road network, and make decisions on whether to carry out large-scale coordination; The other is mobile agent, which is responsible for implementing large-scale traffic control and guidance coordination between regions. When traffic congestion occurs in a certain region, the mobile agent in the region initiates collaborative calculation, formulates collaborative strategy, and migrates to adjacent regions according to the routing strategy, so as to implement the corresponding signal timing scheme of the collaborative strategy and release guidance information, so as to achieve the purpose of optimizing the overall performance of the road network The basic framework of agent-based large-scale traffic control and traffic flow guidance coordination is depicted as figure 2.

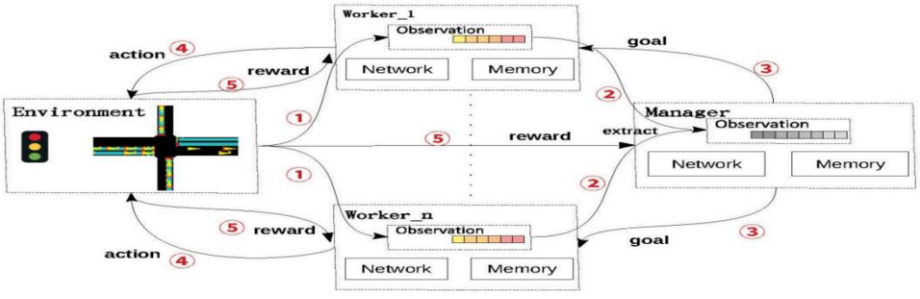

Figure 2. Basic framework of traffic control and guidance coordination

3.2 Cellular Automata Improved Agent

To overcome the low simulation efficiency of agents in traffic simulation, the discussion idea of agent model considering that each agent represents a micro individual in a macro whole is to explore how the interaction between micro individuals affects the macro structure. The same level adopts bottom-up distributed control. On this basis, the hierarchy of agent model and the homogeneity of cellular automata model are used [6,7]. The agent conceptual model of multi-agent system is to define and explain each agent constrained by the organization in the system. Each complex agent can be regarded as a hybrid cellular automata, which is calculated according to the parallel rule function, so as to improve the recognition rate of the model. In the research of agent perception, the abstract perception research of collaborative system is visualized. The intelligent control of agent makes these states change according to the same rules at each time step, thus forming the evolution process of the whole cellular automata. Therefore, the hybrid model of the two can more accurately reflect the interaction between vehicles in the actual transportation system. In addition, the three-phase traffic flow model needs to use the functions of obtaining the front and rear vehicle speed, acceleration, and the front and rear vehicle speed of adjacent lanes, which cannot be achieved by many uploaded codes. Therefore, the initial model framework must take into account the follow-up research, otherwise it will take a lot of energy to change later. The improved cellular automata model is used to establish the road network model. Part of the key codes of the definition process are described as follows:

```
length_ lane=2000; %  Road length
lane=zeros(W,length_lane); %  Create lanes of cells
per_ cell=1.5;  %  The length represented by each cell
per=(length_lane*per_cell)/1000; %  It is used to express the number of vehicles per kilometer (the commonly used expression method of road density in the paper)
q=53; %  Vehicles per kilometer
car_ number=per*q; %  Number of vehicles
%%Iterations
iteraction=2000;
start_ time=1000;  %  Data in 1000 seconds after statistics
%%Set vehicle parameters
v_ max=11;
length_ car=5; %  Conductor
%Slow start and random moderation parameters
p_ start_ car=0.1;
p_ slow=0.01;
…
```

3.3 Coordination Controller Design

The research object is the three lane intersection. The traffic signal fuzzy control system based on fuzzy control designed in this paper is divided into the main design module traffic signal timing control module, which is responsible for controlling the traffic light duration according to the traffic flow and road congestion, so as to disperse the traffic flow and alleviate the congestion. The mathematical model of vehicle average delay waiting, the road model selected in this design is the most common three lane model, that is, each direction includes a left turn, a right turn and a straight line, a

total of three traffic options. In addition, considering that in our real life, right turn vehicles are usually not restricted, so this article will not consider it. The establishment process of fuzzy control rules is similar to the comprehensive process of the judgment basis of traffic police. Based on experience, the fuzzy control rules shown in table 1 can be established.

Table 1. Fuzzy logic rules list

Fuzzy quantity of S		**Fuzzy quantity of T**														
		S					C					L				
		Fuzzy quantity of QC														
		VF	F	C	M	VM	VF	F	C	M	VM	VF	F	C	M	VM
Fuzzy quantity of QN	VF	N	N	N	Y	N	Y	N	N	N	Y	Y	N	Y	N	N
	F	N	N	N	N	N	Y	N	Y	N	Y	Y	Y	Y	Y	Y
	C	Y	N	N	N	Y	N	N	Y	Y	N	N	N	Y	N	N
	M	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N
	VM	Y	Y	N	N	Y	Y	N	N	Y	Y	N	Y	Y	Y	Y

The control rules can be depicted as "IF-THEN" which is a three input single output fuzzy controller and the contol rule can be depicted as $\mathrm{IF}\ QC = A_i\ \ AND\ QN = B_j\ \ AND\ \ T = \mathrm{C}_k,\ \ THEN\ S = D_{ijk}$, where A_i, B_j , C_k , D_{ijk} are fuzzy language defined before. According to each rule, the corresponding fuzzy relation can be acquired as $R_{ijk} = A_i\ B_j\ \mathrm{C}_k\ D_{ijk}$.

4. Simulations

It is set in the road network shown in figure 3, including intersections A, B, C, D, E and F. The distance between each intersection is marked in the figure. The time and process after the straight and left turns in both directions at an intersection are completed is called phase, which is determined after calculation according to the traffic flow at each intersection. The phase of each intersection is different. Starting from the road structure, a cellular automata model of a plane roundabout with inner and outer loops is established. The turning probability is set to be the same, and the traffic flow follows a random distribution. Adopted. AImsun simulation adaptive traffic control system can import the data of CORSIM and Simtraffic traffic simulation models by establishing appropriate data call modules and interface standards [8].

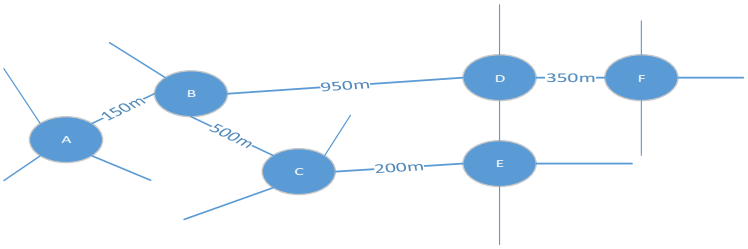

Figure 3. Simulate the road network with intersections.

In the road network, the current control scheme and the fuzzy control strategy based on agent and CA technology are simulated for 10 times respectively and the

average value is taken. The simulation results of four different vehicles are shown in table 2. It can be seen that the intelligent vehicle flow guidance strategy based on agent technology has obvious advantages. Compared with fuzzy control, timing control has better performance in various comprehensive indicators, and the density of road network is significantly reduced. The average speed and delay of vehicles have also been significantly improved, which is a benign cycle control performance in actual road conditions.

Table 2. Simulations result of different control scheme and vehicle type

Index		**Car**		**Truck**		**Bus**		**Total**	
		Mean	standard deviation	Mean	standard deviation	Mean	standard deviation	Mean	standard deviation
delay/ (skm^{-1})	Timing control	135.710	6.354	152.358	8.468	175.332	9.117	141.352	6.543
	Fuzzy control	125.723	4.382	142.770	6.363	153.354	3.401	132.356	4.325
density/ ($vehkm^{-1}$)	Timing control	17.316		0.758		1.002		19.021	
	Fuzzy control	17.052		0.798		1.005		18.229	
flow/ ($vehh^{-1}$)	Timing control	9018		362		289		9245	
	Fuzzy control	8848		331		278		9587	
speed/ (kmh^{-1})	Timing control	1658	0.158	14.338	0.521	14.338	0.548	16.665	0.485
	Fuzzy control	1798	0.338	15.626	0.418	15.009	0.239	17.752	0.325

C# is adopted to write a program: when the traffic lights at intersections are on, the vehicles stop when the red light is on, and when the green light is on, the vehicles pass which road intersects is the opposite. The scheme in this paper is simulated and compared with the traffic network hill climbing method control, and the simulation time is 20min. By weighted averaging the four indicators in table 2, the comprehensive performance obtained is in ordinate units, and the control effect curve in figure 4 can be obtained. The red line is the control effect curve of mountain climbing method, and the black line is the control method curve of this paper. The simulation results show that the comprehensive performance of the improved intelligent vehicle guidance model is better than that of the mountain climbing control method

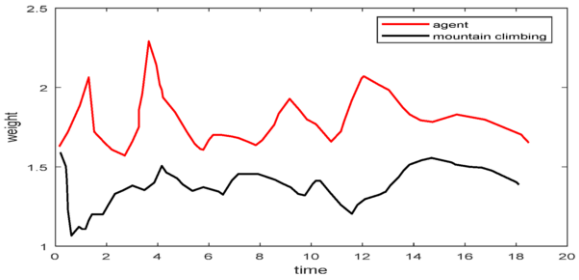

Figure 4. Simulate the road network with intersections.

5. Conclusion

Based on the structure of agent, this paper uses agent theory to model the driver vehicle unit Then cellular automata is used to drive an agent-based traffic simulation model, so that agent technology can more effectively improve the intelligent decision-making ability of vehicle agent. Finally, fuzzy decision-making method is applied to traffic collaborative control, and the improved algorithm is tested and compared through a specific simulation environment. The experimental results verify the reliability of the new simulation modeling method and its comprehensive stability compared with similar algorithms.

References

[1] Du Yanping, Chen Guangwei. Research on intelligent traffic flow prediction decision support system model Coordinated development of science and technology, engineering and economy and society. Proceedings of the fifth annual Youth Academic Conference of China Association for science and technology, 2004, pp.344-346

[2] Application of Dynamic Traffic Routing Model in Travel Guidance. China Water Transport, 2007, 11(7): 191-194

[3] ZHANG Jianqin, LU Feng, WANG Gang, et al. Application of Agent technology in traffic management and travel services. Computer Engineering and Applications, 2009, 45(16):238-241

[4] Zhang F, Xuan H Y, Zhao Q X. Agent-based Simulation of Single-Lane Traffic. Systems Engineering, 2005, 23(2): 95-99

[5] Peng B, Yang Z. Study on Methods for Synergy of Interregional Traffic Control System and Traffic Flow Guidance System Based on Mobile Agent Technology. Proceedings of the 10th International Conference on Intelligent Technologies, 2009, pp.342-347

[6] A Rinkács, Gyimesi A, G Bohács. Adaptive Simulation of Automated Guided Vehicle Systems Using Multi Agent Based Approach for Supplying Materials. Applied Mechanics and Materials, 2014, 474:79-84

[7] Alexandre L, Jean-Marc F. Agent-Based Model for End-of-Life Product Flow Analysis. Resources, 2018, 7(3):42-45

[8] J Hatzenbühler, Cats O, Jenelius E. Transitioning towards the deployment of line-based autonomous buses: Consequences for service frequency and vehicle capacity. Transportation Research Part A: Policy and Practice, 2020, 138:491-507