Hindawi
Journal of Advanced Transportation
Volume 2020, Article ID 8237649, 9 pages
https://doi.org/10.1155/2020/8237649

Review Article

Review of Virtual Traffic Simulation and Its Applications

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Received 7 April 2019; Revised 29 July 2019; Accepted 9 October 2019; Published 19 June 2020

Academic Editor: David F. Llorca

The increasing number of vehicles in cities brings new challenges to urban traffic management. Analyzing and modeling traffic is of great practical significance to urban intelligent traffic management. In this paper, the existing traffic simulation research is reviewed and summarized. Firstly, the crowd modeling and crowd animation are analyzed by referring to the idea of crowd simulation. Secondly, it compares and analyzes various existing car following technologies, and points out that animated traffic simulation is a hotspot in traffic simulation research. And then the concept of affective computing is integrated into the traffic simulation, considering the impacts of drivers' emotion on vehicle driving and it is pointed out that the emotion-driven traffic flow is more authentic. Finally, combined with the status quo, the existing research drawbacks are analyzed, and the direction of future traffic simulation is pointed out.

1. Introduction

With the ongoing development of human society, the number of cars has increased sharply, resulting in more traffic congestion on urban roads, which has become one of the important factors curbing social development and human life. The continuously changing traffic conditions has brought new challenges to urban traffic management. Vehicles have a wide range of traffic behavior characteristics. Thus, it is imperative to adopt scientific methods to analyze and simulate traffic. The development of Internet of Vehicles has thoroughly changed the future mode of vehicle operation, and brought traffic big data to the city. The virtual simulation combined with real traffic data provides technical support for traffic simulation. Integrating vehicle animations into urban traffic scene simulation can enhance the reliability and visibility of simulation and also provides scientific basis for traffic design, traffic planning, and traffic monitoring [1], making it possible to implement intelligent traffic management.

Traffic simulation refers to reconstructing traffic on the road with the help of virtual reality technology. Iowa driving simulator is an early autopilot in a virtual environment [2–4]. Traffic is a complex process involving drivers, vehicles, roads and traffic environment [5]. In the literature [6], a control method of vehicle cooperative behaviors is achieved by generating a special-temporal pattern of a reaction diffusion system. While vehicle motion can be controlled by human driving behavior, vehicle can be regarded as a man-controlled agent. Therefore, it is an effective research method to simulate and analyze traffic animation by referring to the ideas of crowd behavior animation.

Given the demand for intelligent traffic management, this paper systematically analyzes the mainstream methods and the frontier progress of traffic simulation from the combination of crowd simulation, vehicle animation, affective computing and traffic simulation in order to provide reference for researchers in this field.

2. Crowd Simulation

The driver controls the vehicle through his driving behavior, and the traffic can be understood as the behavior of the agent controlled by the person. Therefore, traffic can be regarded as a special type of crowd movement, and can be researched on the basis of the idea of crowd simulation [7].

2.1. Crowd Simulation Model. In the past few decades, scientific researchers have done a lot of research on crowd simulation, and made remarkable progress on crowd evacuation, pedestrian crowds, crowd formation, traffic simulation, and swarm simulation [8]. The existing mainstream crowd simulation technologies can be divided into macro and micro. Macro model compares crowd movement with some physical phenomena and constructs the corresponding particle model. This model focuses on simulating the gathering and flowing characteristics, regarding crowd movement as fluid and gas, and viewing crowd as a single aggregation system. With a global perspective, this model can be used for rough analysis and its advantage is fast simulation. The real-time model AA-FVDM (The Accident-Avoidance Full Velocity Difference Model), which was built on continuous dynamics, unified overall planning and collision avoidance [9]. It can simulate large-scale traffic flows (tens of thousands of vehicles) with realistic and smooth effects and can effectively control the global navigation of the crowd. Distortion tends to occur when individuals are carefully observed, typically true with hydrodynamic model. Virtually, crowd differs from fluid in that the crowd do not fully comply with the physical laws of the fluid, and has certain autonomy (such as direction selection). Crowd simulation is obviously deficient in the fine-grained simulation effect.

Micro model is widely used, and can be combined with new algorithm in the field of artificial intelligence. Its basic idea is the individual simulation of each agent and to optimize the model itself [10]. Micro model describes the crowd by quantifying the individual behavior reasonably, and focuses on the relationship between individuals and crowd. Discrete model and continuous model are the mainstream of micro model. Cellular automaton model is a representative of discrete model, which can simulate the evacuation behavior of human in emergency situations [11–13]. Helbing's social force model is a typical representative of continuous model, which can simulate the congestion phenomenon of the crowd at the exit [14]. This model mainly describes the relationship between individuals in the crowd. Individual's movement behavior is determined by various forces, including the driving force to the target, the repulsive force of avoiding others or objects, and the attraction of the exit, as shown in formula (1).

$$m_i \frac{dv_i}{dt} = f_i^{driven} + \sum_{i(\neq i)} f_{ij} + \sum_{w} f_{iw}. \quad (1)$$

Here, f_i^{driven} represents the driving force of pedestrians to the target, f_{ij} represents the interaction force between pedestrian i and pedestrian j, and f_{iw} represents the forces between pedestrian i and the obstacle. With the combined effect of these three forces, pedestrians constantly update their positions and tend to the target position. m_i is the mass of pedestrian i, and v_i is the current speed of pedestrian i.

However, with the use of social force model for animation simulation, it is easy to perform local crowd motion jitter, which affects the visual effect of simulation. In recent years, there have been many improved models. Saboia et al. introduced mobile grids to improve the social force model [15]. In practical application, the two models can be combined, the macro model is used to drive global navigation, and the micro model drives individual behavior.

Mutual information has been used to describe the degree of anomalies and chaos in complex groups and can be used to describe the overall situation of traffic flow, such as congestion, accidents and so on [16, 17]. Additionally, some methods and ideas in physics are also worth using for traffic flow modeling [18].

2.2. Crowd Simulation Animation. Crowd simulation animation research involves many theories and methods related to computer vision, artificial intelligence, and psychology and so on. In 1987, Reynolds published a classic paper on bird flock animation, which better simulated the aggregation behavior of birds in nature [19]. Using behavior set and action set to control pedestrian behavior, and build virtual pedestrian behavior animation on the road is an early exploration of pedestrian animation [20].

An important part of crowd simulation animation is crowd navigation, that is, how to control individual motion path and avoid collisions between individuals. Jin et al. proposed a simple and effective method to control crowd scene, and set an active variable of global planning and a motion variable of itself for each virtual human [21]. In the literature [22], a data structure of virtual scene has been built, to automatically extract the required data from spatial analysis of virtual human navigation. OCEAN personality model can be used to create and improve crowd diversity, but this method mainly discusses the scheme of distinguishing individuals in the crowd, without specifically discussing how to use personality to drive behavior in an escape [23]. In order to create a complex running formation in a crowd, existing crowd data can be mixed to generate new crowd animations. It creates a predictable spatiotemporal crowd behavior and introduces a deformable crowd model into the crowd. With crowd data being coded, this method controls the formation and individual motion trajectory [24]. For a large-scale crowd, Maim et al. established a real-time crowd simulation and rendering system, which can generate crowd morphology using a small number of virtual humans [25]. Thalmann and Musse's monographs on crowd simulation summarized some basic methods for constructing crowd simulation [26]. Kim analyzed the crowd from the perspective of physical force and interaction, simulating thousands of agents in complex scenes [27]. Ren considered different group attributes of the crowd, such as social groups, tourists and guides, to control the transformation of groups [28].

In recent years, researches on crowd simulation animation began to focus on the use of movement data of real persons, and combined the overall control of crowd formation to improve the efficiency of crowd animation. For example, real crowd motion video is used to obtain human motion information, establishing data-driven crowd animation simulation [29]. Making use of video information can improve the credibility of virtual crowd simulation [30]. In order to improve the crowd rendering efficiency, Kulpa et al. proposed to introduce LOD selection equation to improve the efficiency of crowd collision detection without reducing the viewing effect of users (collision detection is no longer performed in distant crowds) [31]. Many scholars have conducted studies on human body detection, and these results also provide technical references for further exploration of crowd movement information collection. Kapadia put forth a multi-agent behavior framework, which simulated complex multi-role interactions and controlled the flexibility and automation of multi-agents [32]. Guy et al. aiming at the uncertainty of crowd movement information acquisition, proposed an information-theoretic method to measure the similarity of measured crowd data [33]. Hoyet et al. aiming at the complexity of pushing animations generated by physical computation, studied how to use motion capture technology to generate pushing animations between virtual humans, and analyzed the users' visual feelings about the test animations [34]. Kratz et al. aiming at monitoring dense crowds, proposed a crowd tracking method based on the crowd spatial-temporal model [35]. In dense crowds, it is rather difficult to track individuals' behaviors with the usual method. Based on the spatial-temporal change in the crowd movement, it is feasible to predict individual movements by exploring the potential crowd movement pattern.

Combining crowd simulation experiment based on crowd simulation model and animation, researchers can quantitatively study and visualize crowd behaviors, set the empirical formula for crowd behaviors, and simulate crowd movement scenes with different parameters, including crowd evacuation, crowd gathering and crowd tracking. Besides, the simulation experiment can also analyze the influence of different factors on the simulation effect. Seen from the published literature, the existing crowd simulation methods pay more attention to the study of crowd behaviors, and have achieved some results. However, the existing simulation methods seldom involve the study of crowd emotions, and do not fully consider the social factors of the crowd, such as physiological, psychological, emotional and other factors. Simulation technology with the integration of various social factors is an effective method to study crowd simulation in the future.

3. Traffic Animation

Traffic simulation has gradually developed with the advancement of computer technology, which adopts computer digital model to reflect the complex traffic phenomenon. From the perspective of simulation experiment, traffic simulation can reproduce road traffic and reflect the driving behaviors of vehicles on the road. It can present the spatial-temporal changes of traffic flow, and achieve complex and heterogeneous traffic simulation [36, 37]. Traffic simulation is to apply the traffic flow theory to animation, which, by computer system, mainly simulates the movements of vehicles at a certain moment in a traffic network. Traffic animation consists of three modules: road networks modeling, vehicle movement modelling and traffic animation drawing [38].

Cellular automata model was mainly used in early traffic flow [39], which consisted of a series of movement rules and traffic rules that should be complied with in vehicle movement, including various random variation rules, such as driving behaviors and external interfering factors [40]. The simulation granularity of cellular automata model in virtual traffic environment is not fine enough, and the simulation effect is low fidelity.

The car-following model is the most widely used model in micro-simulation theory. It mainly describes the following behavior between two adjacent vehicles running on the one-way road where overtaking is restricted. The existing research results are mostly limited to theoretical models on the basis of statistical physics. The classic intelligent driver model (IDM) mainly simulates car following behavior on the highway, which is not suitable for urban road traffic simulation. To address the congestion of urban road traffic, various car-following models are proposed to keep traffic flow smoothly, such as improved coupled mapping car-following model [41], model of capturing driver's car following behaviors [42], extended car-following model [43, 44], improved IDM model [45], etc. Focusing on local stability and asymptotic stability of car-following model can improve the performance of dynamic traffic flow [46]. The framework of general modeling for car following behavior can be created to identify different regimes in driving [47].

Additionally, infrastructure cooperation system also has an impact on drivers' car following behavior [48]. A car-following model is to describe the behavior of a vehicle following one ahead, which has a significant impact on traffic management, smooth roads and safe driving. The existing car-following models are not enough to study human behaviors, and do not consider the psychological activities of drivers. If human factors are taken into account in future car-following model, the traffic conditions in complex driving situations will be improved to some extent. The comparative analysis of various car following technologies is shown in Table 1.

Vehicle simulation in the form of animation is a research focus in simulation model [49]. The literature [50] dwelled on the integration of the systems of multi-body vehicle model and human-body mathematical model from vehicle driving dynamics perspective. Interactive vehicle simulation is a relatively early vehicle animation, which can simulate the autonomous behaviors of vehicles [51]. Sewall et al. realized the traffic flow of large-scale road network through synthetic animation [52]. With the use of the idea of agent, they have made remarkable progress in simulating the traffic animation of urban road network [53, 54]. Wilkie team used 3D virtual technology to reconstruct traffic flow scenarios (see Figure 1) [55].

Later traffic animation simulation scene is more complex and the animation effect is more realistic. In the literature [56], researchers studied micro traffic simulation in terms of road model and vehicle behavior model, and introduced quantitative traffic behavior characteristics of drivers. In terms of traffic roads, most of literature focuses on various lanes in traffic [57]. Micro hybrid traffic animation involving cars and motorcycles, can reproduce traffic behaviors based on lane and nonlane that are commonly seen in urban scenes [58]. Real-time traffic animation fusion model uses real data to achieve simulation results (see Figure 2) [59, 60].

In the reference [61], VISSIM, a micro-simulation model, was used to evaluate the capacity of the expressway. Taking the eight-lane urban expressway in India as an example, the simulation model was used to estimate the value of passenger car unit of different vehicle types. Visualization of vehicle data is an indispensable part of traffic animation [62]. The comparison of various traffic animation technologies is shown in Table 2.

Table 1: Comparative analysis of various car following technologies.

Year	Researcher	Car-following model	Considerations	Effect
2007	Hank	Modified coupled map car-following model	Relative velocity between several pairs of neighboring vehicles in the front	Inhibit traffic jam
2012	Chen	Car following behavioral based on empirical trajectory data	Correlation between drivers' behaviors	Reduce traffic turbulence
2012	Farhi	Extended linear car-following model and min-plus traffic model	Effects of inhomogeneity and driving expectations on transient and static traffic conditions	Dispersal of traffic without passage
2013	Li	Full velocity difference (FVD) car-following model	Local stability, asymptotic stability and Lyapunov stability	Improve dynamic performance of models
2014	Yu	Extended FVD, sensing two different delays in going forward and speed	Effect of time delays on the stability analysis	Inhibit traffic congestion
2016	Lu	Improved IDM model, adding the acceleration adjustment based on vehicle spacing	Effect of vehicle distance on vehicle speed	Shorten the start-up time of vehicles

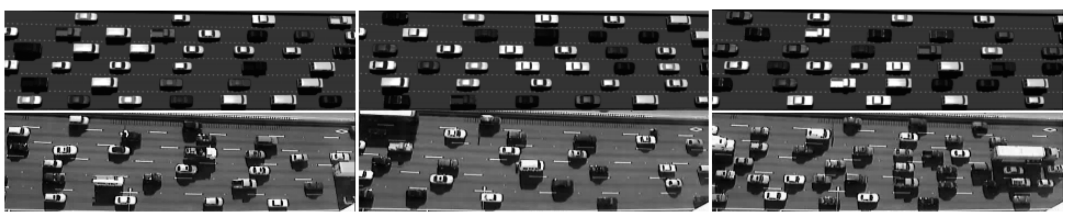

Figure 1: Reconstruct traffic flow according to the video data.

(a)

(b)

(c)

Figure 2: The synthesized traffic flows. (a) The synthesized traffic flows on a curvy road. (b) The synthesized traffic flows on a traffic-light controlled road. (c) The synthesized traffic flows on an urban highway network.

4. Combination of Affective Computing and Traffic Simulation

At present, there are 200 million vehicles and more than 200 million drivers in China. The large driving population and unsafe driving behavior will lead to frequent traffic accidents and heavy casualties. The actual traffic situations are quite complex. While driving in complex traffic conditions, the driver is affected by his emotions besides routine driving behaviors [63]. Emotion-driven traffic flow is more realistic. Driven by different emotions, drivers will adopt different driving strategies and vehicle simulation technologies should

Table 2: Comparison of various vehicle animation technologies.

Year	Researcher	Simulation technology	Data driven	Simulation scene	Scale	Effect
2010	Sewall	Simulating the continuous dynamics of traffic networks	No	Highway, interchange, and road exit	1000 vehicles	Fast and effective
2012	Shen	Following-guiding	No	Urban roads (parallel roads, elevated highways, signalized intersections)	4 lanes/100,000 vehicles	Realistic, smooth
2013	Wilkie	Measurement of in-road sensors	Yes	Highway	6 lanes	Consistent with real traffic flow
2013	Puvvala	Use VISSIM model to evaluate the value of passenger car unit of various vehicles	No	India highway	8 lanes	Satisfactory
2013	Liu	Quantify drivers' traffic behavior characteristics	No	Virtual traffic environment with real-time interactive needs of users	153 lanes/600 vehicles	Realistic
2016	Lin	Interactive hybrid traffic animation system	No	Highways, urban roads (a mixture of automobiles and motorcycles)	3 lanes, 11 intersections/159 vehicles	Attractive
2017	Yang	Interactive control	Yes	Reversing and irregular behaviors	10000 vehicles	Highly realistic
2018	Chao	Texture synthesis	Yes	Curvy road, traffic-light controlled road and urban highway network	2–4 lanes/10,000 vehicles	Highly realistic

achieve the corresponding animation effect. When traffic is congested, drivers' emotions can affect the traffic flow. For example, when angry, drivers are prone to take actions like acceleration, overtaking and so on, thus aggravating traffic congestion. Calm driver may take driving actions such as queuing patiently, waiting for street lights, etc. Therefore, it is of great research significance to analyze the emotions of drivers. Emotion-driven virtual simulation technology is the key point of traffic simulation.

Since emotion is an indispensable variable for crowd movement, it is necessary to introduce the theory and method of affective calculation into traffic simulation. Researchers can model vehicle crowd emotion based on the researches on agent emotion model. Compared with the research on individual emotion model, there are very few studies on crowd emotion model, and most of the existing results are in the field of psychology. The key to the crowd emotion model is to address the transmission of emotions among individuals, that is, emotional contagion. Until 1993, Hatfield et al. published the only systematic work on emotional contagion, claiming that individuals automatically and continuously imitate others' facial expressions, sounds, gestures and behaviors in interaction, and tend to capture others' emotions all the time [64]. This process is defined as emotional contagion. However, their research only focused on qualitative results and lacked quantitative methods for reference. Barsade compared emotional contagion to ripple effects, that is, emotional contagion has a great impact on the behaviors in a crowd [65]. Walter et al. studied the spiral effect for continuous emotional contagion [66]. Currently, the international literature on computational emotional contagion is very rare and the relevant reports are mainly the work of Paiva and Bosse et al. [67, 68]. These studies, using the NetLogo multi-agent tool, focus on the absorption of emotions between individuals. Among them, Bosse et al. proposed a numerical model of agents' emotions by referring to the ideas of physics. It needs be pointed out that their model lacked descriptions of the agents' perceptions and behavior selections, and the physical meaning of the main formula is not clear. Liu et al. studied the emotional transmission of crowds in the crowded railway stations [69]. From the perspective of social psychology, personality, individual attention and group size in crowded environments can affect the emotions of groups and individuals [70]. Lv used emotional contagion to simulate the crowd movement under the political rally scenes [71]. Xu simulated the generation and contagion of panic emotion under multi-hazard circumstances [72]. Xue applied emotional infection to crowd queuing simulation [73]. The above affective computing models and methods have laid a theoretical foundation for the studies on traffic.

It is one of the potential researches in the future to combine affective computing with vehicle simulation. Traffic simulation will be realized with autonomy. To a certain extent, it will prompt the development of traffic modeling technology. For example, with the combination of various models like personality model and emotional contagion model, the study not only focuses on vehicle movement itself, but pays more attention to the driver's emotion as well as the influence of vehicle emotion contagion on driving behaviors. At present, the research on this aspect has not been carried out in depth. Some preliminary explorations have been made by learning the driver's parameters (emotions, habits, etc.) [74]. Lu put forward an adaptive AR model from the perspective of the driver's initiative, taking into account the validity of the driver's prediction, the driver's reaction time and the types of the drivers [74-75]. He put forward a personality model of animated heterogeneous traffic behavior, integrating the personality model into the traffic simulation, combining low-level simulation parameters with high-level personality traits, modeling heterogeneous traffic behaviors and making the traffic simulation effect much closer to the actual traffic flow. To study traffic simulation from the driver's perspective, it is necessary to consider the influence of driver's emotions on driving behaviors. We can observe the effects of vehicle emotional infection from different perspectives [76].

5. Future Prospects

Traffic simulation involves physics, cognitive science, human behavior, computer and other related disciplines. After decades of rapid development, a large number of research results have been accumulated in the fields of traffic simulation, and driving psychology modeling, etc., and even some corresponding traffic simulation software have been developed. However, as traffic simulation has quite high requirements for simulation efficiency and effects, the existing simulation effects are not enough to show various complex traffic scenes. Thus there are still many difficulties and challenges in the simulation technology of traffic, which needs to be further studied.

(1) Traffic simulation based on big data: Traffic big data is currently a typical application of big data. Most of the existing traffic simulation models have implemented the prototype system on the ordinary workstation, but they cannot simulate and deduce the large-scale passenger flow and vehicle flow. From the perspective of intelligent transportation vehicle management, to establish various scenarios of vehicle simulation (such as vehicle monitoring, traffic warning, emergency dispatch, etc.), it is essential to render the large-scale traffic flow. To reproduce traffic simulate in a real way, simulation model, simulation system and computing hardware will be highly required. The existing effects of traffic simulation are not enough to meet the needs of intelligent traffic management, which needs to be further studied.

(2) Traffic simulation based on driver factors: The existing vehicle simulation models are mostly based on mechanical model and constructs the motion behaviors from the perspective of objective mechanics. They seldom combine cognitive science and few of them take human factors into consideration. Traffic is a complex process, such as the mixed intersection where vehicles and pedestrians coexist, and the driver plays a decisive role in the vehicle driving behaviors. Seen from the perspective of safe driving, the vehicle is also personalized, and can perform a wide variety of psychological activities. The driver's self-quality is the decisive factor of the vehicle driving (such as path planning, lane change, overtaking, car following, etc.), and the driver's psychological factors (especially the driver's emotion) cannot be ignored. There are a lot of achievements in the field of psychology, which can provide valuable references. However, these models are too complex to be simply transplanted into those studies on traffic simulation. In reality, to realize traffic simulation, it requires more suitable psychological model, cognitive model and even emotional contagion model. How to integrate driver factors into the traffic simulation, and how to apply these results to the vehicle movement simulation becomes a challenge, which needs to be further studied.

(3) Traffic simulation combined with sound: Sound is an indispensable part of the process of vehicle driving, and vehicle simulation with sound is more realistic. In fact, there are various noises in urban roads, such as various sounds produced by car motors, horns, various types of vehicles (such as fire trucks, police cars, ambulances, etc.). More often, it is the superposition of the sounds of various vehicle. Currently, the animation simulation of traffic only focuses on the movement of the vehicles, and does not consider the sound of the vehicle in motion. Traffic simulation is still in a silent world, and the simulation effect lacks authenticity. With the help of FMOD or WWISE in the game design, it needs to be further studied on how to realize the simulation of various superimposed sounds to improve the authenticity of traffic simulation.

(4) Traffic simulation in complex scenes: Pedestrians and vehicles are the main subjects of urban traffic, and it is common for them to mix in complex scenes on urban roads, involving pedestrians, vehicles, roads, environment. Simulating the mixed traffic of various moving subjects can reproduce urban traffic more realistically. The static subjects include traffic roads and traffic planning. The road system is affected by many external factors, such as weather conditions [77], external environment, temporary traffic control, etc., and thus, it is highly random and open. For example, traffic accidents and vehicle failures will both affect the movement of vehicles. It is urgent to uniformly model traffic anomalies in traffic simulations [78]. Dynamic subjects include people, vehicles and traffic signals. Pedestrians, nonmotor vehicles and motor vehicles constitute the main subjects of complex traffic. The complexity of simulated subjects makes it more difficult to model traffic. Meanwhile, the traffic situation also varies dynamically along with time and space. The existing traffic simulation mainly considers the conventional traffic simulation under simple conditions. Therefore, how to truly show the traffic in complex scenes needs to be further studied.

(5) Vehicle simulation and decision-making: With the increasing number of autonomous and semi-autonomous vehicles, hybrid traffic roads (automobiles, motorcycles, bicycles and pedestrians) are becoming more and more complex, and the requirements of vehicle simulation are getting higher and higher. The existing decision-making of vehicle simulation is usually based on rules, and is impossible to address all emergencies. Vehicle simulation should be combined with artificial intelligence to help on-line decision-making. Artificial intelligence includes three modules: perception, decision-making and control. The research work in many fields, such as integrating multiple sensors (interior/exterior of vehicle) to obtain a large amount of environmental information, combining in-depth intensive learning to optimize the driving routes and achieve vehicle control, meeting different driving needs, emotional driving and so on, will be very important in the urban global traffic management, accidents prediction (or insurance company liability/cost management) or driving decision-making guided by artificial intelligence.

6. Conclusions

Traffic simulation technology is a hotspot in the field of crowd research in recent years. It can be widely used in urban traffic simulation, road congestion identification, urban traffic decision support, etc. The goal of simulation is to achieve motion simulation with high computing efficiency, vehicle autonomy, and realistic effect. Based on the requirements of intelligent urban management, this paper reviews various models of traffic simulation and animations. From the perspective of the overall research framework and research ideas, it is still an effective method to research traffic simulation with the use of crowd behavior animation. This paper focuses on the comparative analysis of various car-following models in traffic animation, and proposes integrating affective computing into traffic simulation. Through the vehicle network monitoring technology, the vehicle and personnel information can be obtained, and the drivers' emotion can be perceived in time. It is of great practical significance to analyze the emotions of drivers. The emotion-driven virtual simulation technology is the key point of traffic simulation. At the same time, taking the actual traffic demands into account and aiming at the drawbacks of existing researches, some problems to be further studied are proposed. The solution of these problems will contribute to the continuous improvements of modeling traffic and animation, thus making the traffic animation under complex traffic conditions more realistic.

Conflicts of Interest

The authors declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work; there is no professional or other personal interest of any nature or kind in any products, service, and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled.

Acknowledgments

This work was supported by Natural Science Foundation of Zhejiang (Grant No. LY20F020007), Ningbo Science, Technology Plan projects (Grant No. 2019C50024, 2019B10032) and K.C. Wong Magna Fund in Ningbo University.

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