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Research and Development on Individual Virtual Intelligent Vehicles

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Abstract. Aimed at the individual virtual intelligent vehicles, the individual vision behavior and decision-making behavior of virtual intelligent vehicles are mainly studied. The vision perception picture and fuzzy neural networks decision-making picture are developed and the virtual intelligent vehicles on the platform of dynamic intelligent traffic environment have been built by use of the EONSDK. It not only has improved the reality of traffic environment, and but also can make out the different traffic environment and can simulate various road accident circumstances.

Introduction

In recent years, the death rate of traffic accidents is more and higher in the world [1]. In order to improve road safety, people should have a clear understanding on the traffic flow in the planning and implementation of traffic control, in conducting induction in a crowed road environment and in dealing with traffic accidents. Therefore, microcosmic simulated traffic system becomes the hot research [2].

The interaction of human-vehicle-road can be simulated by using the microcosmic simulated traffic system on one vehicle level. The real situation of the traffic flow can be reappeared. By using the simulated data, traffic situation can be analyzed and forecasted. The traffic control scheme can be evaluated. The traffic accidents are therefore greatly reduced. Virtual reality has the three characteristics of impressibility, interactivity and imagination. Therefore, the reality of traffic simulation can be improved by applying virtual reality technology, computer graphics and imagery technology, artificial intelligence technology in microcosmic traffic flow.

In the exist microcosmic traffic simulation systems, the virtual vehicles have little intelligence and have the certain patterns [3]. The individual driving behavior has no been considered so that the simulation of traffic scene is unreal and the data of analysis and forecast is incorrect. Therefore, the present research will mainly be focused on the individuality of the vision and decision-making behavior of virtual intelligent vehicles. And at the same time it is realized by using EONSDK technology. The reality of the virtual traffic environment is improved. The real state of the traffic flow is reappeared effectively.

Integrate Structure of Dynamic Virtual Intelligent Traffic Scene

The reality of the Dynamic Virtual Intelligent Traffic Scene is mainly exhibited in the quality of the three-dimensional scene and the interaction process with the users. The rendering effect of the 3D virtual scene is closely related with the impressibility and real-time property of the system. The reliability of the simulation results is determined by the reality of the virtual vehicles and various types of traffic incidents.

Therefore, Dynamic Virtual Intelligent Traffic Scene includes: (1) establishing realistic 3D static virtual scene in the premise of ensuring real-time demands of system. Virtual bodies are able to reflect traffic environment truthfully and to satisfy immersing of a consumer. (2) establishing motion models and information gathering models of the virtual intelligent vehicles. The virtual intelligent vehicles can gather traffic information and make real-time decision. The virtual intelligent vehicles can simulate various dynamics characteristics of real vehicles, and can perform various driving behaviors such as accelerating, decelerating, braking and overtaking. (3) simulating driving behavior of individuality drivers. In real traffic environment, the drivers' behavior is influenced by the character, experience, habits, age, and even the mood. It is said that the driving behavior is personalized and stochastic. The driving behavior of virtual intelligent vehicles is not isolated. It can make real-time decision according to the traffic environment. The reality of virtual intelligent vehicles is the key of building virtual scene and is the key of improving the reality of microcosmic traffic simulation systems.

Virtual Driving Behavior

Virtual intelligent vehicles are the most dynamic and random components in the virtual traffic scene. Each virtual intelligent vehicle has different dynamic performance and driving habits. Therefore each vehicle has different vision and decision-making behavior.

Visual Perception Behavior of the Virtual Vehicles. Firstly, all the information on the road is put in the information database of the environmental information background. The information on the road is dynamically obtained by using the visual scanning nodes of the virtual vehicles. The scan-line length is the visual distance. The scanning range is the visual scope. The attention of the virtual vehicles is reflected by the scanning frequency. The higher the scanning frequency is, the higher the attention concentration is. Finally, the scanned information is collected into the visibility filters to judge the visibility of the objects.

In order to ensure the rapid moving virtual vehicles to obtain real-time information, the visual perception of previous virtual vehicles is totally relied on the information database. It is assumed that virtual vehicles are fully aware of all the information on the road, which is inconsistent with the limitations of human vision [4].

In addition, the high-speed "tunnel vision" phenomenon will lead to a visual impact. Therefore, in the present study, the virtual vehicles choose different scan frequency, length and range to obtain the information on road, according to the attention of the drivers and the vehicle speeds. The framework of the visual perception of virtual vehicles is shown in Fig. 1.

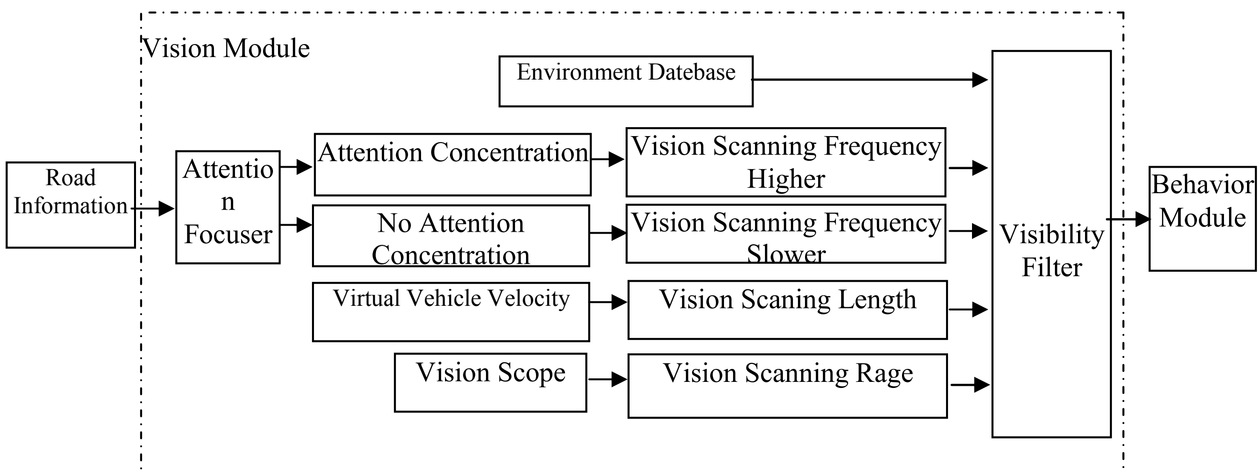

Fig. 1 Framework of the visual perception of virtual vehicles

Decision-making Behavior of the Virtual Vehicles. A six-layer VFBP decision-making controller based on FNN model is designed. In the controller, the visual information of the virtual vehicles, i. e., the distance d_a and angle φ_a between the vehicle and obstacles are set as input variables, and the actual driving speed and the driving angle increment Δθa are set as output variables. Traffic rules and driving experience are distributed to the network in advance. Personalized decision-making behavior of the virtual vehicles is simulated by adjusting the membership function according to the driver's expectation [5]. The framework of the VFBP decision-making controller is shown in Fig. 2. The decision-making behaviors include collision avoidance, overtaking and following.

In the prototype structure of the virtual vehicles, information processing node VD_AutonomousVehicle is secondarily developed with the six-layer FNN model. It is the core of the virtual vehicles. It responses for receiving traffic information on the road from the visual nodes, processes personalized analysis for decision-making, controls the driving behavior of the vehicles.

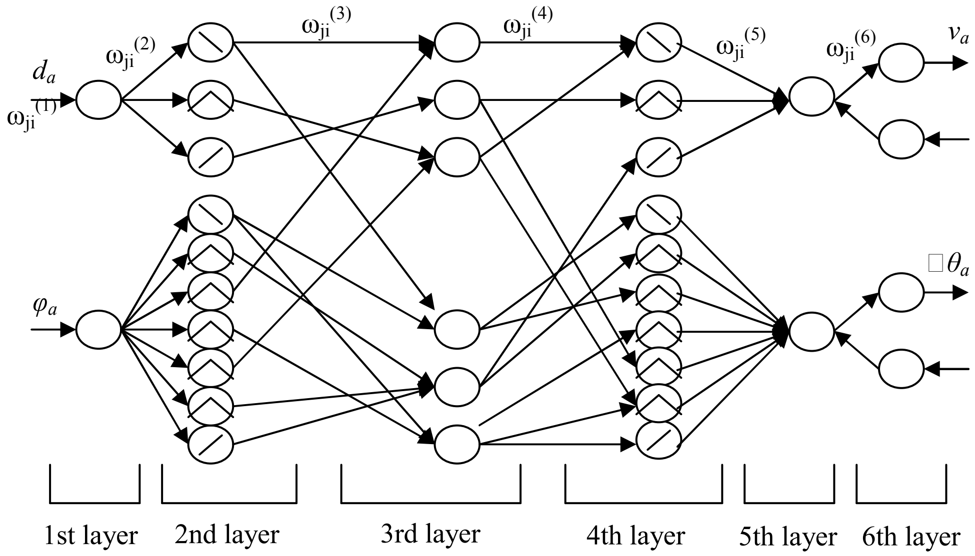

Fig. 2 Framework of the VFBP decision-making controller

Realization of the Virtual Driving Behavior

As shown in Table 1, the prototype structure of the virtual vehicles is constructed by certain hiberarchy. Visual perception nodes are mainly responsible for obtaining road traffic information by adjusting the scan length, scan range and scan frequency. The distance and angle between the virtual vehicles and the obstacles or pedestrians are obtained according to the visual perception theory as shown in Fig.1. The three time interpolators, GoForward_TSensor, Driving_TSensor and Action_TSensor send continuous time pulse to the information processing nodes, realizing the continuous movement of the virtual vehicles. The paternity relationship between the nodes in the prototype structure is helpful to the description of the space location and rotation angle of the virtual vehicles.

A number of attribute domains are defined in the information processing nodes to describe the characteristics of the virtual vehicles and communicate with the environment. Different kinds of virtual drivers and dynamic performance of the virtual vehicles can be defined by setting the initial attribute values of the virtual vehicles at system initialization [6]. The detailed descriptions of the attribute domains of the information processing nodes in the virtual vehicles are shown in Table 2.

After initiation of the system, the virtual vehicles are in a traveling state. The time interpolator, Diving_TSensor starts up. It is ready to receive traffic information, make decision and implement driving behaviors.

For example, the information processing nodes of the virtual vehicles make decision according to the road condition after receiving the pulse from the time sensor GoForward_TSensor. The location and rotation angle of the virtual vehicles is adjusted according to the real-time calculated Translation and Orientation, in order to realize driving behaviors such as overtaking and lane-changing.

The information processing nodes of the virtual vehicles calculate the step length increment according to the instantaneous speed when receiving the time pulse and calculating Translation and Orientation. In the present study, pulse frequency of the time sensor is set to 0.01 seconds. Therefore, the step increment of the vehicles is the traveling distance in 0.01 seconds at the current instantaneous speed. Various speed-related driving behaviors of the virtual vehicles such as accelerating, decelerating, braking and overtaking can be realized by adjusting the step increment. The speed and acceleration of an object can be calculated by the information processing nodes of the decision-making module class (CDecisionMaking). The current instantaneous step increment can be calculated by CMotion module class.

Table 1 Construction of the prototype structure of the virtual intelligent vehicles

Node	Type	Function description
Vehicle00X	Frame	Root node of prototype structure
Vehicle00XDOF	DOF	location information of automobile on concrete section
3DModel	Frame	3D model and collision surround box
Vision_detect_area	Frame	Visual sense checking surround box
Vision	Collision	Visual sense checking node, gains road surface traffic information of road surface
VD_AutonomousVehicle	SDK	Information processing node being responsible for decision-making handling action controlling
GoForward_TSensor	TimeSensor	Make an automobile continue running on the road
Driving_TSensor	TimeSensor	Make the information processing node can real time gain and refresh traffic information
Action_TSensor	TimeSensor	Be used to carry out the decision-making command

Table 2 Attribute region of information processing nodes of virtual intelligent vehicles

Region	Type	Data type	Function description
GoForward_TS	eventIn	SFBool	Received pulse from GoForward_TSensor node
Driving_TS	eventIn	SFBool	Received pulse from Driving_TSensor node
Action_TS	eventIn	SFBool	Received pulse from Action_TSensor node
SetStart	exposedField	SFBool	A signal whether the automobile node is active
AspectSpeed	exposedField	SFFloat	Expectation speed of automobile
Speed	exposedField	SFFloat	Current speed of automobile
Acceleration	exposedField	SFFloat	Current acceleration of automobile
Session	exposedField	SFInt32	Current section that automobile being at
LaneNumber	exposedField	SFInt32	Current lane that automobile being at
Translation	exposedField	SFVec3f	Location coordinate of automobile on straight line section
AnglePosition	exposedField	SFVec3f	Location coordinate of automobile on arc section
Driver_Type	exposedField	SFInt32	Character type of driver
Decision	exposedField	SFString	Decision-making

The key code of the main program procedure is as follows:

```
void VD_AutonomousVehicle::FieldChanged(int ID){
  if(m_bAllStart==TRUE)       // Examine if capital node be activated
          switch (ID) {
          case FID_Driving_TSensor:        // Receive continuous pulse of Driving_TSensor
 m_VD_Vision.GetVisionInformation();      // Receive and handle traffic information
 m_VD_DecisionMaking.DecisionMaking(); // Decision-making process
```

```
m_VD_Motion.TakeAction();                // Receive decision-making instruction
break;
        case FID_GoForward_TSensor:      //Receive continuous pulse of GoForward_Tsensor
        m_VD_Motion.On_GoForward_TSensor();   // read information of road database
break;
        case FID_Action_TSensor:      // Receive continuous pulse of Action_Tsensor
        m_VD_Motion.On_Decision_TSensor();      // Correspond implementative driving behavior
break;
default:
CEonBase::FieldChanged(ID);
 }}
```

Realization of the Virtual Intelligent Vehicles

The prototype system is developed in Windows XP by using virtual reality development platform EON Studio 5.0, Visual C++ 6.0and EON SDK secondary development package. EON SDK is used for developing of information processing nodes for virtual vehicles, realizing the information transmission between Visual C++6.0 and EONX, connecting of the Visual C++6.0 and Access databases, performing simulation of the intelligent traffic scene based on EON Studio.

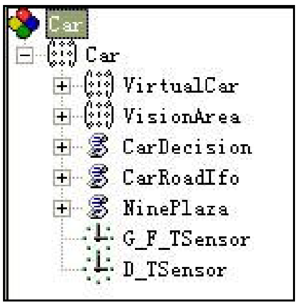

Fig. 3 Inner prototype node of the virtual intelligent vehicles based on EON

Table 3 Explanation of the inner prototype node of the virtual intelligent vehicles

Name	Node Type	Explanation
VirtualCar	Frame node	The 3D model of intelligent vehicles
VisionArea	Frame node	The 3D model of pre-collision area
CarDecision	SDK node	Including various driving behavior and logic decision-making program
CarRoadIfo	Script node	Leaving the relate parameters of vehicles and roads
NinePlaza	Script node	Leaving the real vision information of vehicles
G_F_TSensor	TimeSensor	Controlling vehicles to continuous running along roads
D_TSensor	TimeSensor	Realizing various driving behavior except to continuous running along roads

The inner prototype node of the virtual intelligent vehicles based on EON is shown in Fig. 3, and its explanation is shown in Table 3. The virtual intelligent vehicles developed in the present study are able to realize the functions of simulating the various driving behavior, such as the mature, the novice, the common, the cautious. And at the same time the various dynamics characteristics of real vehicle can be simulated. The surrounding vision information can be described in text. The driving log of virtual intelligent vehicles can be shown, such as the acceleration, the deceleration. The running interface of virtual intelligent vehicles is shown in Fig. 4.

Conclusion

In the present study, the visual perception and decision-making behavior of the virtual intelligent vehicles is investigated and analyzed, and is built by using EONSDK. And the effective platform of virtual intelligent vehicles is constructed. The constructed platform can be used for setting different traffic scenes and simulating different traffic accidents.

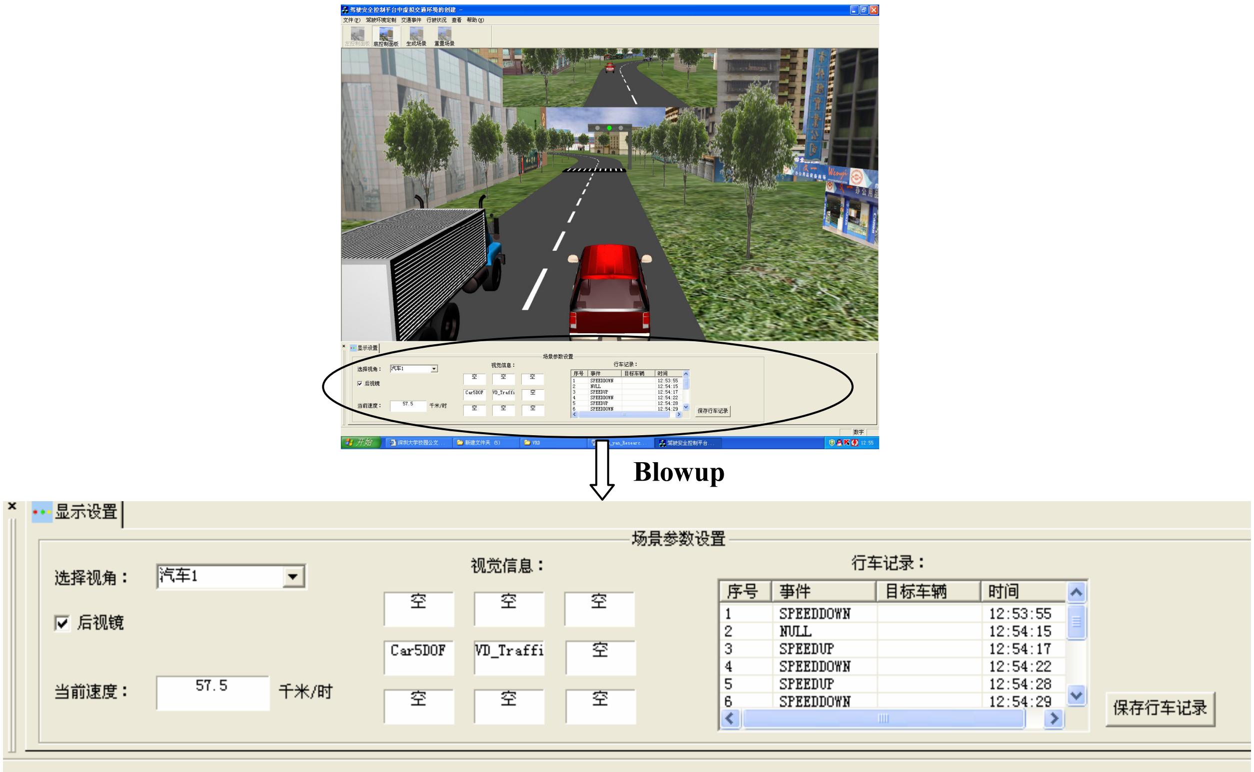

Fig. 4 Running interface of virtual intelligent vehicles

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