2018 International Conference on Computational Science and Engineering (ICCSE 2018)

Direction Control of Unmanned Vehicle Based on Artificial Neural Network

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Keywords: Artificial neural network, Direction control, Unmanned vehicle

Abstract: Unmanned vehicle is a typical high-tech complex, which uses computer, modern sensor, information fusion technology, communication, artificial intelligence and autonomous control technology. Steering control is the key technology of unmanned vehicle autonomous control. The goal is to control the vehicle to keep the desired driving automatically. Based on structure of artificial neural network, a model of direction control for unmanned vehicle is established. The simulation results show that the system can work normally and the control accuracy can meet the requirements of the unmanned vehicle at low speed.

1. Introduction

How to accurately analyze and digitally model the real driver's control behavior is the premise of realizing the simulation and performance evaluation of driver-vehicle-road environment system [1]. It is also the focus of the research on the control strategy simulation design stage of advanced automotive electronic control systems such as electronic steering, electric control and even auxiliary driving. The driver behavior models in the initial stage of the study were developed based on classical control theory or modern control theory, such as the optimal preview control model and the optimal preview curvature model. The control system using neural network is a way of realizing artificial intelligence by simulating human neural network. It has the ability to remember past experience and recognize environmental changes, and in order to better adapt to the environment, can change their own structure or work procedures according to certain rules. This system has become an important field of cybernetics in the age of India. At present, this research has been carried out in an all-round way and has been applied in many fields. Nowadays, the application of artificial neural network in intelligent vehicle control shows great vitality. Drivers are guided by the principle that the movement of the car is as consistent with the expected track as possible. The more skilled the driver is, the smaller the driving error is. Neural network ensemble refers to training multiple individual neural networks and synthesizing their conclusions. Neural network ensemble can significantly improve the generalization performance of learning system. It is regarded as an engineering technology with broad application prospects. It has become a research hotspot in the field of machine learning and neural computing. When the vehicle is close to the object, the driver's nervousness will increase and his attention will be focused on the object. When the danger is close to the object, the driver's physiology and psychology will be nervous to some extent. The driver's heart beat will quicken, the action frequency will increase and so on. Many researchers believe that there is a definite link between the stimulation of the front car and the reaction of the rear car, that is, there is a definite causal relationship between the front and rear car movements. Intelligent driving behavior analysis has always been a key and difficult problem in intelligent vehicle research. Facing the environment of complex dynamic unknown highway and urban road, its complexity and uncertainty often lead to wrong behavior decision-making, and manual interference is needed in the driving process. Compared with real drivers, artificial intelligence has limited information processing ability in road traffic environment. In order to ensure the fluency of intelligent driving, many researchers and scholars have carried out a lot of research work on intelligent driving behavior based on machine learning, aiming to make intelligent vehicles have better autonomy and intelligence by acquiring and expressing the knowledge of driving behavior [2].

  DOI: 10.25236/iccse.18.056

2. Model Establishment of Direction Control Behavior of Vehicle Based on Neural Network

2.1 Input Parameters.

Every neuron is very simple, but such a large number of neurons, such complex connections can evolve colorful behavior [3]. At the same time, such a large number of neurons and external receptors between the various ways of connection also contains unpredictable responses. In the practical application of neural network, there may be many variables that affect the system. It is impossible to take all the variables as input variables of the network. When selecting variables, we must select variables that have a significant impact on the output of the network. If the two input variables are closely related, this choice is not very satisfactory. Because the correlation input can make the network too sensitive to a statistical characteristic in the sample, aggravate the excessive coincidence phenomenon, thus weakening the generalization ability of the network. Therefore, the factors that affect the output are selected as the input of the network, but there should be no close correlation between the input variables. This is the basic principle that should be followed when selecting variables. In the process of driving a vehicle, there are many factors that affect the driver to turn the steering wheel, such as preview distance, predefection angle, steering wheel current corner position, vehicle speed and vehicle roll acceleration. We take the preview distance, predefection angle, steering wheel current position, vehicle speed and vehicle inertia centrifugal force as the input parameters of the neural network. Artificial neural network is a system that simulates the structure and characteristics of human brain neural network by means of engineering technology. Artificial neurons can be used to construct neural networks with different topological structures. It is a simulation and approximation of biological neural networks. Neural network has strong adaptability and learning ability, nonlinear mapping ability, robustness and fault tolerance. Fully applying these neural network characteristics to the control field can make the intelligent control system take a big step forward. As the controlled system becomes more and more complex, people have higher and higher requirements for the control system, especially for the control system to adapt to uncertain, time-varying objects and environments.

2.2 Neural Cell Number.

In multilayer networks, the determination of the number of neurons in hidden layer is the key to success or failure. Therefore, choosing the number of neurons in hidden layer is very important. If the number is too small, the network can get too little information to solve the problem; if the number is too large, it will increase the training time, it is difficult to complete the training within the time people can accept. There are two main methods to determine the number of hidden layer neurons: one is experimental patch method, that is, using the same sample set to train the network with different hidden node number until the weight is no longer changed and the network is stable. Then, according to the minimum test error, the number of hidden nodes in the network is determined. The other is the Pyramid rule, that is, from the input layer to the output layer, the number of nodes is decreasing. In this paper, the pyramid rules and experimental patchwork method are combined. First, two hidden neurons are used according to the pyramid rules, and then the experimental method is used to verify. If the experimental results are unsatisfactory and cannot meet the requirements, then different hidden neurons are used. The output layer of the network is the final result of the network. It is also a direct reflection of the quality of the network. When a driver rotates the steering wheel while driving a car, he needs to rotate the steering speed at a certain angle in a certain period of time. Therefore, we take the speed of steering and the steering angle as the output parameters of the network. The transfer function of the output layer is linear transfer function, because if the transfer function of the hidden layer is function and the transfer function of the output layer is linear function, the nonlinear relationship between the input and output can be learned, and the output layer can get any output value by using the linear function, without any numerical conversion [4].

2.3 Output Parameters.

The axonal function is mainly the conduction of information, and the direction of conduction is transmitted from the origin of the axon to the end. Usually, the end of the axon is divided into many terminals, which form a mechanism called synapse with the dendrites of the latter neuron. The axonal terminals of the former neuron are called the anterior membranes of synapses, and the dendrites of the latter are called the posterior membranes of synapses; the narrow gap between the anterior and posterior membranes is called the synaptic gap. The information of the former neuron is transmitted from its axon to the terminal, and then affects the posterior neurons through the synapse. In the process of vehicle driving, the process of driver driving the vehicle can be roughly divided into three parts: information perception, trajectory decision-making and control. Among them, manipulation control behavior is the specific manifestation of human movement control behavior and body motion intelligence. Usually, human body kinesthetic intelligence includes two kinds of abilities: one is the ability to control one's own body movement, such as gymnastics and diving. The two is the ability to manipulate objects skillfully, that is, using hands and bodies to manipulate and control external objects. From the point of view of human body structure and motion mechanism, driver's behavior of controlling automobile belongs to the category of human body motion control. It is necessary for the driver to control the vehicle motion based on his knowledge of the dynamics and kinematics of the vehicle. The cerebellar neural network model, which simulates the characteristics of human cerebellum participating in motion control and the neural network structure, is a local neural network based on table inquiry input and output. The content of the table can be changed by network learning algorithm, so that it has the ability of multi-dimensional nonlinear mapping from input to output. Because of its good nonlinear approximation ability, it has been widely used in nonlinear real-time control in complex dynamic environments such as manipulator control in recent years.

3. System Design of Direction Control Behavior of Vehicle Based on Neural Network

3.1 Hardware Design.

The modeling and prediction of driving behavior is mainly aimed at some dangerous and abnormal driving behaviors, which can effectively reduce the probability of accidents and provide help for intelligent driving and decision-making of vehicles. The presentation and processing are embodied in the connection of the network processing unit. Artificial neural network is a kind of non-programmed, adaptive and brain-style information processing. Its essence is to obtain a parallel and distributed information processing function through network transformation and dynamic behavior, and to imitate the information processing function of human brain nervous system in different degrees and levels. The hardware design of neural network steering control system includes the selection of steering sensor, the design of DSP electronic control system and the design of SCM communication conversion control system. The steering sensor is selected from the steering and torque sensor of American company. The sensor is integrated with dual-output relative angle position sensor, single-output absolute angle position sensor, double-output torque sensor, two concentric independent rotor bodies, and the floating rotor torque measurement design independently designed by the company. There is almost no hysteresis phenomenon. The function of DSP electronic control system is to control and execute motor, collect steering and torque signals, and communicate with industrial control computer. The control chip of electronic control system adopts DSP single chip microcomputer. The control system collects real-time signals such as the position of steering column and engine speed, calculates the steering speed of steering column, and then transmits them to the industrial computer through the single-chip microcomputer communication conversion system. The industrial computer transmits the output parameters calculated by neural network to DSP electronic control system through SCM communication conversion system. The DSP electronic control system decodes the acquired data, then controls the executive motor, rotates the steering column, and drives the steering wheel. The function of SCM communication conversion system is to convert the serial data mode of industrial control computer into the parallel communication data mode of DSP electronic control system when the industrial control computer sends data to the DSP control system, and convert the parallel communication data mode of DSP electronic control system into the serial port of industrial control computer when the DSP control system sends data to the industrial control computer.

3.2 Software Design.

Firstly, the neural network is constructed by using the neural network toolbox in MATLAB environment. Then the neural network is trained by using the collected data. Then the simulation is carried out by using the data. Then experiments are carried out to see if the simulation results are satisfactory. If the result is not ideal, the network training function, learning function, learning rate and other parameters will be changed to rebuild the network. If there is still no satisfactory result, the network node will be added. Using VC++ language to establish dialog box and human control in the case of a driver driving a car on a typical road, seven parameters such as preview distance, predeflection angle, vehicle speed, steering wheel angle position and vehicle roll acceleration, steering wheel rotation angle and rotation speed at a certain time are collected, and these data are guaranteed. Save to the Access database. Then add the control to read out the seven parameters from the Access database and put them in memory as an array. For example, reading 1000 sets of data, declare a two-dimensional array of 7 1000, for data placement. Then open the MATLAB computing engine, put the array into the MATLAB space, and divide the input-output matrix of 7x1000 into the input data matrix of 5x1000 and the output data matrix of 2X1000 in the MATLAB space. These two input output matrices are used to train BP neural network. Then it can start the automatic steering, read the steering wheel position signal from the DSP electronic control system in real time, get the vehicle speed signal from the speed sensor in real time, read the roll acceleration signal from the roll acceleration sensor, and obtain the preview distance and predeflection angle signal from the machine vision system. Using the five signals obtained in real time, the neural network is simulated, and the two data of steering wheel rotation angle and steering wheel rotation speed are obtained by simulation. Then the two data are encoded according to the communication protocol, and transmitted to the DSP electronic control system through the single chip microcomputer communication conversion system. The DSP electronic control system decodes the received data, controls the motor rotation according to the rotation angle and rotation speed, and drives the steering column. In order to meet the vehicle speed requirements, the steering control frequency is 20 hz. When the next steering angle and steering speed data are transmitted, whether the last one is completed or not, it is executed according to the current data obtained.

4. Direction Control Experiment and Result Analysis

The experiments were carried out on straight roads and step roads respectively. First, the driver drives the car to collect data, and then drive automatically. The driving speeds are controled at 5km/h, 15km/h, 25km/h respectively. Each speed test was carried out three times. The results of the test are shown in Table 1.

Table 1. Comparative experiment result of direction control of driver's vehicle and unmanned vehicle

	Nearest distance between wheel imprint and road side			
Speed	Experiment on straight roads		Experiment on step roads	
5 km/h	0.52m	0.50m	1.63m	1.37m
15 km/h	0.51m	0.52m	1.71m	1.59m
25 km/h	0.48m	0.44m	1.46m	1.32m

The experiment proves that the neural network steering control system can work normally, and the control accuracy can meet the requirements of low-speed vehicles.

5. Conclusion

Unmanned vehicles have developed rapidly in recent years, but they have been developing for a short time in China, especially machine learning for driving behavior, which has always been the bottleneck in the field of intelligent vehicles. On the one hand, the development of machine learning limits the development of intelligent vehicle. On the other hand, it is due to the complexity and particularity of driving behavior. This requires researchers to search for new learning algorithms and learning systems while studying direction control behavior. Using neural network, we can realize the direction control of the unmanned vehicle at low speed. The research on the structure of artificial neural network can further promote the development of unmanned vehicle. The problem is the when unmanned vehicle running at moderate or high speed, there are no experiment which can verify the same result. It brings some limitations to practical applications.

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