Research on Automatic Operation Control Algorithm of High Speed Train Based on Artificial Neural Network

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Abstract. With the development of social economy, the demand for transportation is also growing. High-speed railway has become an important part of the transportation system. It is not only an inevitable requirement for the development of the national economy, but also an important support for the implementation of the national strategy. Therefore, whether the high-speed train can operate smoothly and safely is related to the passenger's life and health and property safety. This requires accurate control of the automatic operation of the high-speed train during the driving process. At present, China's research on the automatic operation control of high-speed trains is still in its infancy. The problems of traction and brake system actuator failures that may occur during long-term running of trains can be solved by artificial neural network-based modeling methods. The automatic operation control algorithm of high-speed train running process is established. The self-correcting control strategy based on artificial neural network is used to realize the speed tracking of high-speed trains. The high-speed train visual simulation system is established by virtual reality technology and verified on the artificial neural network platform. The effectiveness of the proposed automatic operation control method.

1. Introduction
How to construct a scientific and perfect professional training model for certified public accountants is a subject worthy of in-depth study by our front-line educators [3]. The CPA professional (or professional direction) personnel training model in institutions of higher learning should be structured in terms of professional settings, personnel training objectives and training specifications, teaching content and curriculum, teaching methods and teaching methods, teaching management, and teaching evaluation.

The high-speed train automatic operation control technology has made great progress and development for decades. With the rapid development of industrial technology, the speed of train operation is also constantly improving, especially the rapid development of high-speed trains, making the traditional method of dealing with low- and medium-speed trains unable to meet the requirements of high-speed train tracking control. The traction and braking control of high-speed trains have time-varying characteristics such as model uncertainty, system nonlinearity and external disturbances. In addition, there may be input restrictions during traction braking; in traditional train operation control, the parameters are usually obtained from the experiment. But for high-speed trains, precise parameters cannot be obtained experimentally. Because of the use of artificial neural networks for simulation, it is
very important to use artificial neural network simulation to control the automatic operation of high-speed trains.

2. Analysis of the characteristics of high-speed train operation
The high-speed railway is a complex system that combines traction, brake operation control technology, communication interconnection technology, high-strength lightweight materials and structural technology, and diagnostic technology. Among them, the train operation control system is particularly important, which can coordinate between systems. Work to maximize the potential performance of each system, use real-time monitoring and overspeed protection of train running speed and running interval with effective technical means to ensure safe and efficient operation of trains, improve passenger comfort, and reduce the work intensity of train drivers. And improved working conditions [1]. However, the quality of current high-speed train operation still depends on the driving experience of the train driver, and the train control system can only assist the train operation. In order to ensure the safety of train operation, ride comfort, efficient transportation and low energy consumption, high-speed trains need a more intelligent train control system. The key to the realization of these goals is to develop automatic train operation control technology [2].

3. Analysis of automatic operation control algorithm for high speed train based on artificial neural network

3.1. Analysis of the main points of artificial neural network simulation
Artificial neural network is an intelligent algorithm obtained from the mathematical simulation of the human brain to receive and process information. It is a hot research topic in the field of high-tech. In recent years, many disciplines such as biology and neuropsychology have been studied in the direction of artificial neural networks, in order to further understand the brain, so that the function has human-like intelligence.

(1) According to the traction braking characteristics of high-speed trains and the force analysis of the running process, an artificial neural network model is constructed to establish an automatic operation control algorithm for the high-speed train running process.

(2) Based on the established automatic operation control algorithm of high-speed train, the self-correction control strategy based on artificial neural network is used to track the speed target curve of high-speed train, and the method is compared with the automatic control, which can realize high-speed train. High-precision tracking of the target optimization curve for automatic control.

(3) For the characteristics of difficult test of high-speed train control system, virtual reality technology is used to simulate the system, which effectively simulates the running condition, steering characteristics, traction and braking characteristics of the train under various operating environments and working conditions [3]. And other features, and verify the effectiveness of the automatic operation control method on the system.

3.2. High-speed train running over-automatic operation control modeling analysis points:

(1) Automatic operation control algorithm in the traditional train control research, the train is simplified into a whole to carry out force analysis, ignoring the interaction force between the cars. However, in reality, the link system between the cars is constructed by a spring-damper mechanism, and the train parts are different in attitude, displacement, speed, and vibration characteristics. Therefore, in order to more accurately analyze the real dynamic characteristics of high-speed trains, high-speed trains must be regarded as a multi-mass system [4]. Considering the distribution of traction/braking force, air resistance, restraint force and external disturbance, the multi-mass point automatic operation of high-speed trains is established. The control algorithm is used to design the design of the safe operation control strategy [5].
Figure 1. Artificial neural network modeling logic structure

(2) Aerodynamic effects. The traditional aerodynamic effects of medium and low speed trains are not obvious. However, with the continuous development of technology, high-speed trains with a speed of more than 300km/h are already common. When such trains are in operation, the aerodynamic effect should be significant. If they are not taken into account, they will inevitably run the train. Security poses a major threat. Therefore, the aerodynamic effects must be taken into account, and the corresponding control strategies and methods must be studied to ensure the safety of high-speed trains.

(3) Model uncertainty, nonlinearity and external disturbances during the running of high-speed trains, they are affected by various factors. The slope slope, track environment, wind speed, weather conditions, etc. all have an impact on the additional resistance of the train operation, and it is not easy to measure the accurate train drag coefficient. Therefore, when designing and researching control strategies, factors such as uncertainty, nonlinearity, and external disturbances must be taken into account.

(4) Traction and braking system failure during the long-term actual operation of the high-speed train, traction or braking system failure will inevitably occur, threatening driving safety. The current fault-tolerant control technology has many limitations, and it is necessary to establish a more effective fault-tolerant control system.

3.3. Analysis of Modeling Characteristics of High Speed Trains
Compared with ordinary trains, the main difference between high-speed trains lies in the concentration and dispersion of power systems. The EMUs distribute the power units on some cars. During the operation of the trains, the power units are installed. The carriage provides traction to the entire train. Studies have shown that this decentralized mode structure can effectively improve the running effect of the train. This design makes this type of car not only control, but also can be used to provide passengers with space to ride. Establishing a reasonable automatic operation control algorithm for high-speed train operation is the basis for realizing the research on automatic operation control of high-speed trains. In order to realize the tracking operation of a given "speed-distance" curve for high-speed trains, it must be operated under complex conditions. The high-speed train performs a comprehensive force analysis and uses dynamic equations to describe the dynamic characteristics of high-speed trains to derive high-speed train automatic operation control algorithms.
4. Automatic operation control algorithm analysis process

4.1. High-speed train operation process

The high-speed train operation process is divided into a traction phase, an inert phase, and a braking phase. (1) Traction stage: under the action of the torque generated by the traction motor, the train is subjected to traction and the force of the train is the traction force and the total resistance opposite to the running direction; (2) the idle phase: after the traction motor is cut off, the train No traction and braking force are provided. In this state, the following vehicles are subjected to the full resistance opposite to the running direction. For the convenience of research, the stage can be regarded as a uniform and smooth operation, and the train can be controlled to idle before entering the braking phase. Effectively reduce the traction energy consumption and achieve the goal of energy saving for train operation; (3) Braking phase: The train decelerates or stops under the action of friction braking or traction braking. The force received by the train at this stage is the braking force and running direction. On the contrary, the whole resistance is formed.

4.2. Factors affecting automatic operation control and its measurement methods

There are many factors affecting the automatic operation control, and there are many factors affecting the degree of automatic operation control. It is limited by the existing detection tools and the acquired data information. According to the relevant literature research, the automatic operation control prediction model established in this paper is studied. The sample factors mainly include contact line height, train speed, contact force, power supply voltage, and train passing frequency. At present, the detection technology of automatic operation control is still in the research and development stage, the measurement results are not ideal, and the detection techniques of other parameters are relatively complete and the measurement results are relatively accurate. The measurement of these parameters can provide more for the automatic operation control prediction model. More data to improve the prediction accuracy of the model.

4.3. High-speed train modeling process method

4.3.1. Artificial neural network modelling. The traditional high-speed train modeling is to analyze the force of the train during the driving process. The train is regarded as a rigid single-mass model, and the single-mass mechanism model of the train running process is established. However, the model is relatively simple and the model parameters are the invariance is difficult to accurately describe the
Dynamic system of nonlinearity and uncertainty in the operation of high-speed trains. Therefore, in view of the complexity of the high-speed train operation process and the difficulty and accuracy of mechanism analysis modeling, artificial neural network modeling method can effectively overcome the shortcomings of mechanism modeling, especially under the condition that the actual running data of high-speed train can be obtained, the advantage of selecting artificial neural network modeling is more obvious.

4.3.2. Artificial neural network analysis and calculation. Artificial neural network modeling methods can be divided into statistical modeling and non-statistical modeling. Low-dimensional effective information can be extracted in high-dimensional data, which reduces the difficulty and complexity of analysis. The high-speed train operation process is more complicated. The neural network data-driven method modeling does not need to establish the automatic control format of the system, the self-adaptive ability is strong, and the nonlinear system can be effectively controlled automatically. Therefore, this chapter will select the neural network to establish the high-speed train automatic operation control algorithm of the train.

\[ y(k) = f(y(k-1), \ldots, y(k-n_y); u(k-d), \ldots, u(k-n_u)) \]  

4.4. Analysis of Artificial Neural Network Automatic Operation Control Algorithm

Where \( u(x) \) and \( y(x) \) are the input and output of the system, respectively, and \( f_m(x) \) represents the nonlinear relationship between the input and output of the system. In order to establish a model of linear system input and output, the artificial neural network is also selected as an artificial neural network model, namely:

\[ y_m(k) = f_m(y(k-1), \ldots, y(k-n_y); u(k-d), \ldots, u(k-n_u)) \]  

The artificial neural network not only has the fast self-learning speed and the ability of local approximation, but also has the advantages of simple principle and easy application in engineering, using the input and output data of the research object, and the automatic control of the artificial neural network self-learning process. And to ensure that the error function meets the modeling requirements, you can get a nonlinear model that can describe the input and output relationship of the object. The neural network automatic control can be divided into two different modes: automatic control and offline automatic control. The offline automatic control knowledge simply trains the neural network through the input and output train operation data, which will cause the train operation and the neural network automatic control process. Separate away, and the neural network automatic control can not only satisfy the learning and training of the data of a certain sampling period, but also realize the effective automatic control of the system during the running of the train, and establish the time-varying nonlinear system model adaptation through the neural network. It has stronger capabilities and has been widely used in process modeling. Therefore, the neural network automatic control method is more in line with the requirements of high-speed train modeling. This paper selects the automatic control method to automatically control the high-speed train operation process and verify the built Rationality of the model,
Figure 3. Artificial neural network automatic operation control logic relationship

4.5. Neural network algorithm data output error curve
The operation process of high-speed trains is extremely complicated and nonlinear. The accuracy of using high-speed trains using conventional linear methods is low. Artificial neural networks can approach nonlinear modeling objects with arbitrary precision and have faster learning. Rate, in order to accurately establish the automatic operation control algorithm of high-speed train operation process, this paper adopts artificial neural network for automatic control. \( U(t) \) is the control force during train operation, and \( y(t) \) is the train running speed. \( y_m(t) \) is the predicted output speed of the train artificial model, and the artificial neural network is corrected by comparing the errors between the two data.

4.6. Neural Network Algorithm for Automatic Control Error Analysis of High Speed Trains
It represents the target speed curve, and \( y \) represents the high-speed train speed tracking curve using the artificial neural network control method. \( y_{pid} \) indicates the high-speed train speed tracking curve using the automatic control method. It can be seen from the figure that the artificial neural network control can obtain better control effect; it can clearly obtain the following vehicle speed tracking error curves in two different control methods. The fluctuation range can be seen through the simulation verification. The speed tracking error based on the artificial self-correcting automatic control is in the range of -0.2874 km/h and 0.9365 km/h, and the speed tracking error based on the automatic control is used 2.7656 km/h, 2.5371 km/h, so the artificial neural network control is adopted, the system response is fast, the speed overshoot is small, the tracking speed curve is smooth after the train runs stably, and the speed regulation effect is better. The tracking accuracy is still high in the process of the two speed changes during the initial stage of the train start and the deceleration stage. Meet the high-speed railway operation safe, efficient, on-time operation requirements.

5. Conclusion
As one of the most important transportation tools today, high-speed trains have the advantages of fast running speed, strong carrying capacity, high intelligence, safety and comfort. However, the operation of high-speed trains mainly depends on manual control. Some train control systems have a limited scope of action. In order to meet the needs of China's railway speed increase and the development of intelligent high-speed railways, we should study the automatic operation control of trains. At present, the automatic operation control technology for high-speed trains has been called train operation control. In this paper, the paper studies the actual operation process of high-speed trains, and establishes the automatic operation control algorithm of high-speed train motion based on artificial neural network, which realizes the speed tracking optimization control of high-speed trains. Based on artificial neural network. Modeling analysis has been carried out to further improve the level of automatic control.
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