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Optimization of Control Method of Construction Machinery Manipulator Based on Neural Network

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Abstract: Neural network is one of the important basic knowledge in computer, chemistry and information science, microelectronics technology and other fields. It has good universality in dealing with nonlinear system problems, and is widely used in industrial automation and intelligent control. This paper mainly introduces the mathematical model, algorithm design and implementation method of the construction machinery robot arm, and studies and analyzes its kinematics. Based on the neural network and artificial neuron theory, this paper constructs the robot arm position recognition technology in the object feature database for the characteristics and requirements of the subject. Finally, the function of the robot arm control model is tested, and the test results show that the arm support of the model has a long elongation distance, which can meet the production requirements.

1. Introduction

With the development of industrial production, mechanical equipment plays an increasingly important role in engineering construction. However, most people do not know how to control the manipulator [1-2]. Due to people's lack of concentration, problems such as low work efficiency and low accuracy emerge in endlessly, and some machines are also very embarrassed when they are poor in performance and stability but cannot be used. Therefore, in order to solve the above problems, we must adopt a more scientific and effective method to improve, so as to improve production efficiency and product quality [3-4].

Many scholars have done some research on neural network algorithm. There are a lot of problems in the artificial neural network algorithm abroad, for example, improper selection of model parameters, too few or too small number of input neurons will lead to system error operation, uneven training samples may also cause too much error, which will affect the output results and

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other situations. These conditions have a very bad effect on the optimization work [5-6]. In China, the research on neural network is mainly focused on the industrial manufacturing field, but with the continuous development of automation technology, computer technology and other related disciplines, as well as in-depth research and application. At present, China has mastered the position, speed and accuracy of some robot arms based on artificial intelligence control. Some scholars have studied the structure and function of artificial neural system and proposed to use computers as network units, take neurons as the center, and use their self-learning ability instead of relying on external information to obtain the knowledge needed in the brain's working process [7]. And the support vector machine plays a very important role in the whole brain network system. Therefore, based on neural network algorithm, this paper optimizes the control method of construction machinery robot arm.

With the rapid development of modern industrial automation, manipulator also plays an important role in engineering construction. However, due to the low level of production process control, inadequate understanding of the reliability and stability of machinery and equipment operation, and the lack of professional knowledge and skills, many enterprises in China still use traditional manual operation for mechanical work. Therefore, a method based on neural network technology is proposed to achieve optimal design.

2. Research on Optimization of Control Method of Construction Machinery Manipulator Based on Neural Network

2.1. Manipulator Control of Construction Machinery

The construction robot arm is a kind of robot with high precision, which can control any position of the arm in space. According to the motion track, it can be divided into two types: fixed and moving. In the position control of the construction robot arm, its main task is to dynamically plan the operation process and realize it through the arm automation control system according to the actual situation [8-9]. The motion trajectory method can use the command sequence received by the robot as the input signal to judge whether the operator has done the correct operation according to the given program, and then the system gives an output value as the execution path and position information to the manipulator feedback control mechanism to complete the entire task. Finally, it is dynamically planned through the artificial neural network, so as to achieve the real-time monitoring and regulation of the engineering manipulator. In the actual production of construction machinery, a control mode is usually used, that is, to control the robot arm to achieve the desired purpose. This method can be realized in two forms. The first is to grasp and transport objects through a manipulator. The second is to use the arm force to drive the moving parts to rotate and move, so that the whole operation process can be completed in a short time. For some machines, it is easier to master and the cost is very low. In industrial production, the application of manipulator is very extensive, and has been very good development, but because of its poor working environment, high requirements for grasping accuracy and the need for long-term use and other reasons. Therefore, how to improve the motion speed and positioning accuracy of the robot arm has become the most important, effective and fast control method to solve these problems. Because these two kinds of robot hands have different joint structures and working modes, they also have their own driving methods, control systems, theoretical basis and technical systems. For this kind of robot, all actions are completed by one or more mechanical arms, rather than arbitrarily changing the arm position and motion trajectory. Figure 1 is the joint position control diagram of the mechanical arm [10-11].

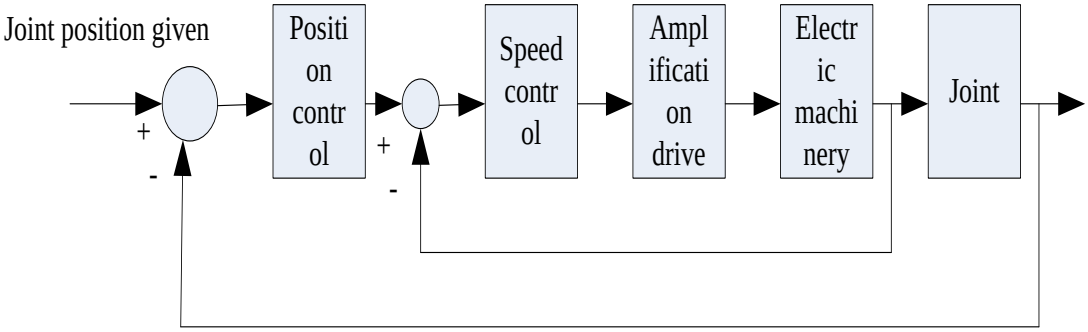

Figure 1. Mechanical arm joint position control diagram

2.2. Classification of Construction Robots

At present, the definition of mechanical arm is basically to use arm bracket, suspension beam and claw to carry objects in the industrial production process. According to different classification methods, the construction robot can be divided into many kinds. For example, according to the motion mode, it can be divided into two types: linear type and curved type; according to the direction of gravity center, it can be divided into gravity push rod type and Newton bar tube type; according to the control mode, it can be divided into fixed, mobile robots and flexible robots. The other is to distinguish according to the working object and control form, and the other is to detect whether it moves through the displacement sensor. According to the action type of the arm, it can be divided into single arm, double arm and multi shot [12-13]. The arm has two or more joints, which can be determined according to the actual situation. If it is a rigid linear walking robot, it belongs to a flexible structural manipulator. On the contrary, telescopic and swinging hydraulic walking belong to a flexible kinematic manipulator - a robot with elastic mechanism. When moving fast or with great inertia in space, it is also called as a robot for sliding, jumping and other action types, including fixed rigid supports suspended with one arm or both hands. The articulated hand has multiple degrees of freedom, and each position can swing and rotate freely to complete the action independently without participating in other loads. The catenary arm is connected by one or more rods. This kind of manipulator is widely used in industrial production. It is a kind of equipment and tools or other auxiliary devices capable of carrying, loading and unloading. Or there may be requirements for high-end positioning accuracy. For example, some welding operations require slings, cranes, etc., which are not highly automated and have low requirements for environmental conditions and are widely used.

2.3. Neural Network Algorithm

The development of neural network has gone through three stages: simplification, theory and application. There are many differences between these two aspects. Simplification, that is, the artificial neuron can form a mathematical model with certain regular functions by simulating the structure of the biological neural system, and at the same time, the computer can also process the input and output the results to the user to achieve the system control goal. In addition, in order to better solve nonlinear problems, people have proposed many new methods, such as probabilistic neural networks, fuzzy logic, linear approximation and other technical methods, to improve its performance [14-15]. The neural network is a method that processes the external information

through the brain of brain cells, then inputs the data into the computer, and changes its own state according to different output signals. In the whole process, it can simulate the response of biological nervous system to unknown environmental changes. In the practical application of artificial neural network algorithm, the first problem to be solved is how to determine the input and output weights and parameters. Figure 2 shows the neural network algorithm model.

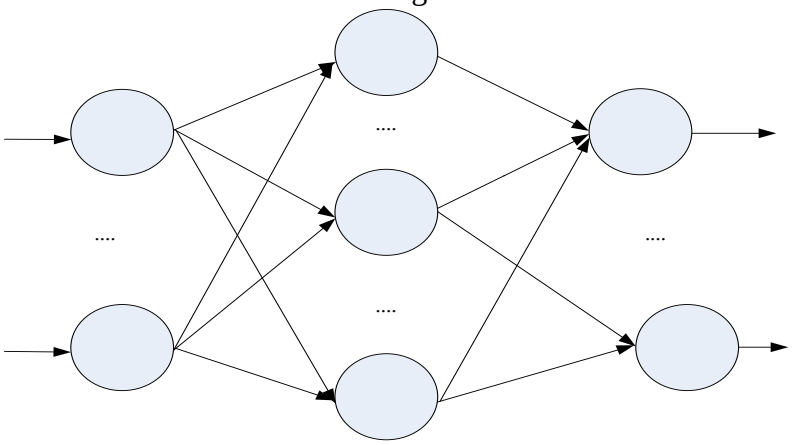

Figure 2. Neural network algorithm model

At present, many methods have been proposed in this regard. One is to map the sample to a vector. This method can directly optimize the model. Another pattern recognition method is to use neural networks to complete the research and training process. The other two are one of the nonlinear network algorithms, which are very good choices for learning and applying to some problems in practice. The algorithm of neural network is to realize the data processing function of human brain through a large number of parallel calculations. In practical application, we need to carry out complex simulation, which requires that the model parameters must have good robustness and sufficient fault tolerance. For different types, size types and different quantity of feature information, they can be selected as input signals to train neural networks. At the same time, considering that neural network structure, system performance and other factors have a large impact on data processing speed and accuracy, analog methods can be used for control. The idea of the neural network algorithm is to process the information in the complex system, transform it into a simple function, and then predict and classify it [16-17].

$$A_{\mathrm{j}}^{i} = down\left(A_{j}^{i-1}\right) \tag{1}$$

The traditional convolutional neural network is usually connected with one or more full connection layers after passing through multiple convolution layers and pooling layers. Its output form is:

$$a_{j}^{i} = f\left(\sum_{\mathrm{i}}^{S} a_{i}(i-1)w_{ij} + b\right) \tag{2}$$

The main purpose of the full connection layer is to combine the classification and differentiation learned in the convolution layer or pooling layer with local information. However, the full connection layer will occupy most of the network parameters, resulting in over fitting. Therefore, the full connection layer is removed and the global average pooling layer is replaced, which makes the model training faster and reduces over fitting.

3. Experimental Process of Optimization of Control Method of Construction Machinery Manipulator Based on Neural Network

3.1. Control Model of Construction Machinery Robot Arm Based on Neural Network

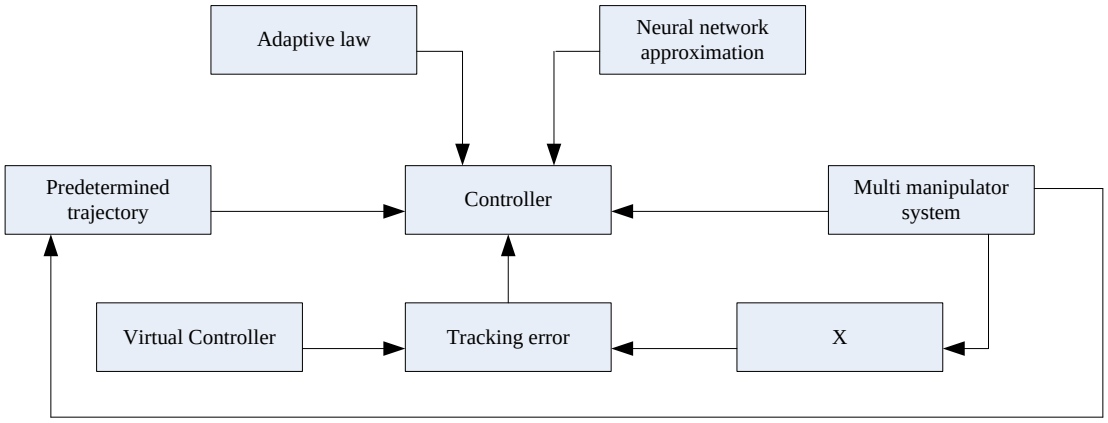

Figure 3. Mechanical robotic arm control system diagram

In order to improve the working efficiency of the robot arm in engineering, this paper designs a model based on the combination of neural network technology, expert system and fuzzy control (as shown in Figure 3) to realize the speed adjustment of the robot arm. Firstly, the optimal motion position is determined by manual observation, and then the PID algorithm is used to complete the trajectory calculation of the end effector joint, and the control signal is output to achieve the position and attitude correction process. The two closed-loop control systems are combined to form a nonlinear model manipulator control system with self-tuning accuracy and real-time correction, which provides a new method and idea for the rapid response of the construction mechanical manipulator. When designing a construction manipulator, it is necessary to choose the overall structure of the robot arm and the position of each joint. A simple, effective, high accuracy, good precision and strong controllability can be established through neural network, and the control function can be easily realized. First of all, ensure that it has a large enough range of motion. Second, consider that it can bear weight and bearing capacity. Finally, in order to simplify the arm structure and reduce the volume to reduce costs, it should also improve work efficiency.

3.2. Performance Test of Control Method of Construction Machinery Manipulator Based on Neural Network

The basic model of neural network is designed and manufactured manually. In this process, we need to test it. Input functions, training samples, and output variables will all affect whether the system performance indicators can meet the requirements. For different types of objects, the results are different. For example, if the workpiece is moved, there will be some parameters such as higher degrees of freedom to control the trajectory of the robot arm and the arm. These factors should be considered in the model. The training process of neural network is a complex and long continuous optimization problem, so when conducting model testing, it is necessary to consider not only the influence degree of various factors such as linear relationship between input and output, nonlinearity and uncertainty on the system, but also the structural processing ability. For different types of data samples, the hierarchical pattern design is adopted. Select an appropriate number of

initial weights according to the actual situation, and then use a minimum cost function to represent all the point-to-point units on each training set.

4. Experimental analysis of Optimization of Control Method of Construction Machinery Manipulator Based on Neural Network

4.1. Performance Test and Analysis of Control Model of Construction Machinery Robot Arm Based on Neural Network

Table 1 shows the quality test data of the control model of the construction machinery robot arm.

Table 1. Control the model performance test

Parameter	Parameter physical significance	Parameter values
L1	The first link length of the mechanical arm	250mm
L2	The second link length of the mechanical arm	200mm
L3	The third link length of the mechanical arm	150mm
M4	First-link mass of the mechanical arm	2kg
M5	Second-link mass of the robotic arm	1.5kg

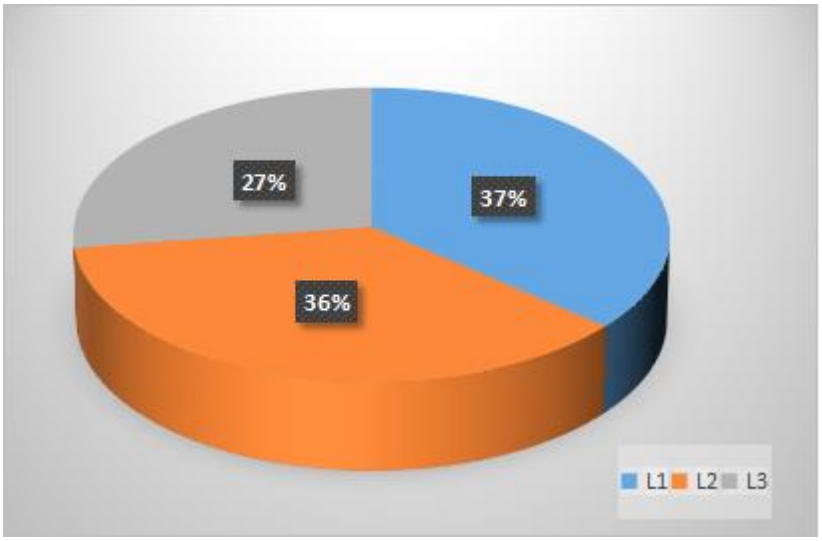

Figure 4. Mechanical arm control performance test

In this paper, the arm control model designed by neural network is used to analyze its performance through the test results. First, the experimental data are processed. After the trained mapping relationship and output are established at the input, the direct drive method is used to convert them into the parameter values required in the standard function for calculation, and the final accurate calculation results are obtained after conversion. Then the Kalman filter algorithm is used as the preset variable, and the arm control model designed by the neural network is used as the

data obtained by minimizing the error between the actual motion trajectory and the expected position of the manipulator to analyze. It can be seen from the experimental test results (As shown in Figure 4) that the arm support of this model can be extended for a long distance, which can meet the production requirements.

5. Conclusion

In the era of rapid development of modern science and technology, automation technology has become an indispensable part of human production and life. Manipulators are widely used in the industrial field as a kind of high efficiency, low cost, and can replace people to carry out some complex operation processes and have low work intensity or are not suitable for people's daily working environment. However, due to its inherent shortcomings, it is also easy to lead to system failure problems that affect the construction quality and safety accidents. Therefore, it has a good optimization effect for the artificial neural network technology in practical applications, and it is of great significance to control the robot arm system.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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