Design of Charging Pile Control System for Electric Vehicle Based on BP Neural Network

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Abstract. This paper presents a design scheme of charging pile control system for electric vehicle based on BP neural network and PID control. The design goal of this scheme is to design a charging pile control system for electric vehicles which is suitable for public parking lot and district parking lot. It can realize fast charging of electric vehicles, human-computer interaction with the system, calculation of consumer price and other functions.

1. Introduction
Under the severe situation of the increasingly serious environmental pollution and the shortage of oil resources in the world, many new industries have emerged. Electric vehicle is one of them, and this kind of vehicle will become a new development direction of the automobile industry. In recent years, the electric vehicle industry is developing rapidly, and is gradually replacing the status of fuel vehicles. Electric vehicle charging facilities play a very important role in electric vehicles. Therefore, while vigorously developing the electric vehicle industry, we should fully coordinate the development of charging facilities. Therefore, it is necessary to study the design and control methods of charging piles for electric vehicles.

2. Neuron structure model
Neural network is composed of neurons. To understand the neural network, we need to understand the structure of neurons and the process of their work. Fig. 1 shows the structure of the neuron model.
3. Structure of BP Neural Network

In 1986, famous scientists such as Rumelhart and McClelland first proposed the concept of BP neural network. This is a multi-layer feedforward neural network, which is trained according to the error back propagation algorithm and can solve many complex problems. Therefore, this neural network is favored by many scholars.

BP neural network can collect and memorize a lot of input-output mode mapping relations, and it can not establish the mathematical equation of mapping relations before working. The structure of BP neural network model consists of three parts: input layer, output layer and hidden layer. The hidden layer can be greater than or equal to one. Commonly used are three-tier topologies, as shown in Figure 2. Generally speaking, BP algorithm first establishes an objective function, calculates the square of the error, and then uses gradient descent method to find the minimum of the objective function. Many scholars have proved that the approximation ability of BP neural network is omnipotent.

BP algorithm has two processes, one is the forward propagation process of signal, the other is the reverse transmission process of error. That is to input information in the input layer, spread down layer by layer, and finally output the results to get the error value. If you want to adjust the data, you need to start from the output terminal and spread up layer by layer. Neurons connect from one layer to the next, and there is no connection between the same layer of neurons. The state of each layer of neurons only affects the state of the next layer of neurons. There are two kinds of AC signals between layers: one is the working signal, the other is the error signal. As long as there is a difference between the actual output and the expected output, the network will begin to look for errors and start the process of back propagation. Error back propagation is a process that propagates from back to front. It is necessary to transmit errors to the units of each layer for checking and checking. The errors are reduced step by step. After repeated learning and training, the weights of neurons are constantly corrected. When the errors of output signals meet the requirements, the training is over.
4. Workflow of BP Neural Network
The flow chart of BP neural network is as follows:

![BP Neural Network Flow Chart](image)

5. Programming process design
The flow chart of the system program is shown in Fig. 4
Fig. 4. Firstly, the user needs to swipe the card. Only after swiping the card, the user can carry out the next charging operation. Next, the charging pile control system will carry out a test, that is, check the connection of the plug and the interface of the charging pile. If the connection is incorrect, the user will see the prompt on the screen and need to replace a charging post to operate again. Only when the plug and the interface are properly connected can the user continue to use the charging pile. Then users need to choose the charging mode. There are three modes to choose in the system: setting the amount of charge, setting the amount of electricity for charging and automatic charging. The first two charging modes require users to set their own charging amount or charge volume, which is more flexible, and users can charge as much as they want. When the charging is completed, the charging switch closes automatically and enters the settlement interface, then the user can swipe the card to settle the account. In the charging process, in order to protect the battery and charging pile, the electrical protection program is designed. If some parameters are abnormal in the charging process, the charging pile will stop charging, thus protecting the charging equipment.

6. Controller of BP Neural Network

Traditional PID controller structure is very simple, and its performance is stable and cost-effective, so people choose to use this control algorithm in industrial control process. However, it also has shortcomings. When the control structure is uncertain and the process is very complex, the traditional PID control can not achieve the desired control effect no matter how to adjust the parameters, because it can not establish an accurate mathematical model. In this paper, a neuro-PID control method is proposed. An optimized PID control method can be obtained by utilizing the advantages of neural network. The structure of neuro-PID control is shown in Fig. 5.
Neural PID control combines BP neural network with PID algorithm, then the input of linear neuron is:

\[ h_1(k) = e(k) \]  \hspace{1cm} (1) \\
\[ h_2(k) = \sum e(k) \]  \hspace{1cm} (2) \\
\[ h_3(k) = \Delta e(k) \]  \hspace{1cm} (3)

The output of the neuro-PID system is as follows:

\[ u(k) = v_1 h_1(k) + v_2 h_2(k) + v_3 h_3(k) \]  \hspace{1cm} (4)

This controller does not need to establish a very precise mathematical model, and constantly train. It can learn in depth according to the results, which can well meet the requirements of the system.

7. **Summary**

This paper presents a design scheme of charging pile control system for electric vehicle based on BP neural network and PID control. This paper studies the BP neural network, understands the BP algorithm and its flow, and puts forward the neural PID control method. It can realize the functions of charging electric vehicles quickly and calculating the consumer price.

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