Application and Study of artificial neural network intelligent control

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Abstract. Artificial neural network is a computing system formed by several very simple parallel processing units connected with each other in a certain way. Its function depends on the structure of the network, the strength of connection and the processing mode of each unit. The system processes information by its state's dynamic response to external input information. It is an important branch of intelligent control. By imitating human brain structure and some information processing mechanism, it can solve the nonlinear, uncertain and large lag system, and has a wide range of applications.

1. Introduction
Artificial neural network is an information processing system which imitates the structure and function of human brain. It is a nonlinear complex network system composed of a large number of processing units similar to biological neurons. But there is a difference between artificial neural networks and the real human brain[1]. Artificial neural network is a computing system formed by several very simple parallel processing units connected with each other in a certain way. Its function depends on the structure of the network, the strength of connection and the processing mode of each unit. The system processes information by its state's dynamic response to external input information.

2. Artificial neuron model
Artificial neuron is the abstract and Simulation of some basic characteristics of human or other biological neurons. Biological neurons are mainly composed of cell bodies, dendrites, axons and synapses. The cell body is the main body of biological neurons, which is composed of nucleus, cytoplasm and cell membrane; dendrite is the nerve fiber extending outward from the cell body to receive the input signals from other neurons; the axon is the longest nerve fiber extending from the cell body to output the electrochemical signal of the cell body; the synapse is the communication connection between each neuron through the axon terminals[2]. In biological neurons, the cell body is equivalent to a micro processor. The dendrite is the input of the cell body, the axon is the output of the cell body, and the synapse is the input and output interface. Due to the different permeability of cell membrane to different ions in cell fluid, there is a difference of ion concentration inside and outside the cell membrane, resulting in negative internal potential and positive external potential. Dendrites and axons are responsible for the input and output of information. Excitatory impulses reach the cell body along the dendrites and accumulate excitatory potentials on the cell membrane; on the contrary, inhibitory impulses reach the cell membrane to form inhibitory potentials. If the sum of the two potentials exceeds a certain threshold, the neurons will produce impulses[3].
Artificial neuron is to abstract the information processing process of biological neuron, simulate the structure and function of biological neuron, and express it with model diagram. The artificial neuron model imitates the process of biological neuron to produce impulse, so a typical mathematical model of artificial neuron can be established, as shown in Figure 1.

The artificial neuron model is a multi input single output structure, which has a weight for each input of the neuron, and its positive and negative simulate the excitations and inhibition of biological neuron synapses[4]. Whether neurons can be activated depends on the threshold \( \theta \). \([x_1, \ldots, x_n]\) is the input vector, \( y \) is the output, and \( f(\cdot) \) is the excitation function. \( w_i \) is the connection strength between neurons and other neurons, also known as weight.

### 3. Perceptron model

The perceptron is a neural network with a single-layer computing unit and consists of linear threshold elements. The threshold value \( \theta \) is incorporated into the weight intensity \( W \), so that \( w_{n+1} = -\theta \), \( x \) vector also increases a component \( x_{n+1} = 1 \), then the output is \( y = f(\sum_{i=1}^{n+1} w_i x_i) \). When the weighted sum of its input is greater than or equal to the threshold value, the output is 1, otherwise it is 0 or -1. The neural network learns by modifying these weights, so as to adjust the input-output relationship of the whole neural network, so that the output of the network is close to the expected output[5].

### 4. Multilayer forward BP neural network

In the artificial neural network, the connections between neurons are diverse, and the connection strength between neurons is plastic[6]. The network can be self-organized by learning and training to meet the requirements of different information processing.

Multilayer forward BP neural network is composed of input layer, hidden layer and output layer. The signal is transmitted from input layer to output layer, as shown in Figure 2. The training algorithm of multilayer forward BP neural network adopts error back propagation algorithm, and the learning process consists of two processes: forward propagation of signal and back propagation of error. In forward propagation, the input samples are transferred from the input layer, passed through each hidden layer, and finally passed to the output layer. If the actual output of the output layer is not in accordance with
the expected output, the error back-propagation phase will be turned on[4]. Error back propagation is to transfer the output error layer by layer from the hidden layer to the input layer in a certain form, and the error is used as the basis to correct the weight of each unit. The forward propagation of the input signal and the back propagation of the error in each layer adjust the weight of each layer to minimize the output error of the network[7]. In the neural network system identification, the neural network is used as the identification model, the input and output state of the object is regarded as the training sample data of the neural network, and the objective function $J=1/2e^2$ is taken as the training target of the neural network, then the network is trained by certain training algorithm to make $J$ small enough.

Artificial neural network PID control is a three-layer BP network with $M$ input nodes, $n$ hidden nodes and 3 output nodes. The input node corresponds to the selected system operation state quantity, and the output node corresponds to three adjustable parameters $K_p$, $K_i$, $K_d$ of PID controller. According to the performance index $J=1/2e^2$, the artificial neural network can update the parameters of PID controller in time, so that the system error can be minimized in the case of serious uncertainty[8].

5. Conclusion
In this paper, artificial neural network PID is used to control the bottom temperature of fractionator. The tower bottom temperature should be stable at the given value, and the control curve is shown in Figure 3.
The control curve shows that the dynamic performance index of artificial neural network PID control is better than that of traditional PID control. Artificial neural network PID has the advantages of short adjustment time, fast response speed and good steady-state performance.

References
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