Crude Oil Measurement Model Based on Artificial Neural Networks

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Abstract: ANN technology is being widely used in many fields, Based on the analysis of artificial neural network, a method using multi-sensor in an improved artificial neural network is put forward for the error compensation and control of crude oil measurement model, experimental data are used to verify the result.

Introduction

Artificial Neural Networks (ANN) is defined as a complex network computing system hat composed of large number of highly interconnected simple processing elements: neurons. It is an effective way to imitate artificial intelligence, which can not only be used as a computational model, but also a cognitive model. Currently, back propagation (BP) and radial basis function (RBF) neural network are the most typical feedforward neural network model. Among these, BP neural network is currently the most popular multi-layer feedforward neural network. Since BP neural network has highly self-learning and adaptive ability, generalization ability and nonlinear mapping ability that can approach any nonlinear continuous function with arbitrary precision, so this paper chooses BP neural network as the research object

Error Compensation of Crude Oil Measurement Based on Neural Network

Through the established multimedia measurement model of crude oil storage tank, it is clear that the moisture content of the oil tank (α)is mainly influenced by many parameters such as the density of water(ρ_w), temperature(t), height(H) and pressure difference(ΔP). Making the four parameters that affect the moisture content as the input of BP neural network model error compensation the output parameter is the predictive value of error ($\Delta\alpha$)of the actual moisture content of the crude oil.

If the input of a first iteration as input parameters ρ_w、 t、 H、 ΔP is $x_i(k)(i=1,2,3,4)$, the output $\Delta\alpha$ is $y(k)$, $y(k)$ is the actual value relative to $x_i(k)$. Squared error of the water content of crude oil is defined as

$$e(k)=\frac{1}{2}[y'(k)-y(k)]^2 \tag{1}$$

If the number is N, then the mean square error is:

$$E=\frac{1}{N}\sum_{1}^{N}e(k)=\frac{1}{2N}\sum_{1}^{N}[y'(k)-y(k)]^2 \tag{2}$$

The goal of neural network learning is to minimize the constructed objective function. The training steps based on improved simulated annealing algorithm of the neural network are as follows :

(1) initialize the parameters, give values to the network weights(ω_{ij}) and the initial

temperature(T_0), select the temperature decay function;

(2) calculate the output($y(k)$) of each training sample($x_i(k)$) and the mean square error E;

(3) amend the wight(ω_{ij}) ,assume $\omega_{ij}^* = \omega_{ij} + \Delta\omega_{ij}$ is in line with the Cauchy distribution;

(4) through the modified network weight(ω_{ij}), recalculat the output($y^*(k)$) with the use of training samples($x_i(k)$) ;

(5) recalculate the mean squared error $E^* = \frac{1}{N}\sum_1^N e(k) = \frac{1}{2N}\sum_1^N [y'(k) - y^*(k)]^2$;

(6) If $E^* < E$, make $\omega_{ij} = \omega_{ij}^*$; otherwise, accept ω_{ij}^* by the probability $\exp(-\Delta E / T_i)$ calculate the probability $\Delta E = E - E^*$, T_i is the current temperature;

(7) Repeat steps three to six, until the mean square error reaches allowable precision

In the process of crude oil measuring, first, use a mathematical model to calculate the water content of crude oil, then draw the predictive value of the moisture content of crude oil with the help of the improved BP neural network to compensate the calculate value of the mathematic model, hence to achieve measurement accuracy and stability of the target, that is:

$$\alpha = \alpha' + \Delta\alpha \qquad (3)$$

α' in (5-15) is the calculated value of the mathematical model, $\Delta\alpha$ is the predictive value of the improved artificial neural network, α is the water content of crude oil after error compensation. The system composition of the improved neural network error compensation is shown in Figure.1

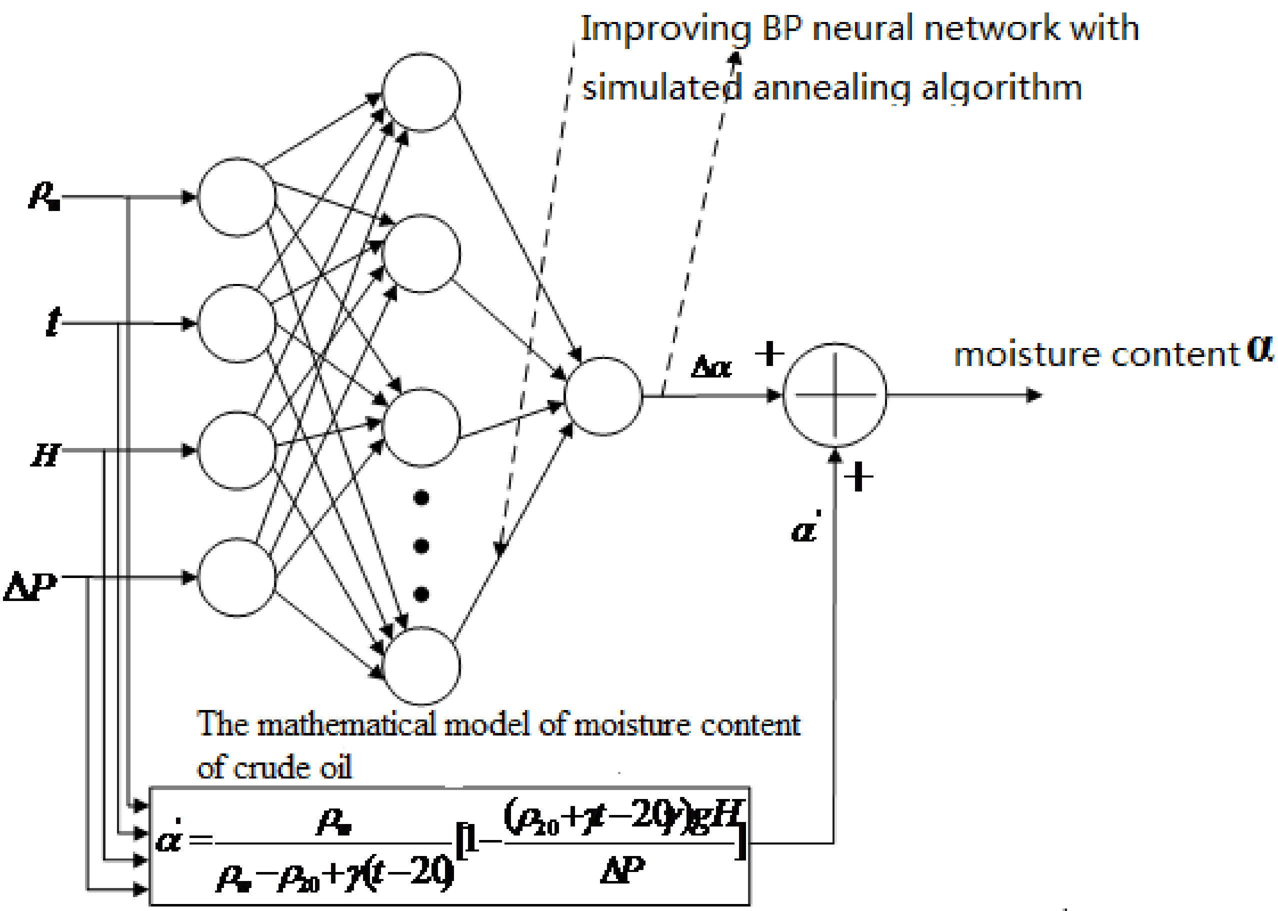

Figure.1 Improved Simulated Annealing BP network error compensation

Experimental design to get neural network training samples

In order to use the improved artificial neural network to model and optimize the water content of crude oil, the work to be carried out first is to get the input/output data sample for learning and testing through experimentations. Because the input of neural network generally contains multiple parameters, and functional relationship between the input and output is highly non-linear, so, to obtain input /output data, many times of multifactorial combined experiments must be carried out .

Since orthogonal test has a balanced distribution, less trial numbers, intuitive and easy-to-analyze results, and is easy to analyze the main effects of each factor, So in this article, orthogonal test is used to obtain training samples and test data. Orthogonal experimental design and the results are shown in Table 1.

Table 1 Orthogonal test table of obtaining training samples

	volume ratio of oil - water	Temperature	Error of moisture content	Valid
Exp1	1（4:1）	1（0℃）		
Exp2	1（4:1）	2（15℃）	12.55%	
Exp3	1（4:1）	3（23℃）	−12.32%	
Exp4	2（3:1）	2（15℃）	7.25%	√
Exp5	2（3:1）	3（23℃）	−6.92%	√
Exp6	2（3:1）	1（0℃）		
Exp7	3（2:1）	1（0℃）		
Exp8	3（2:1）	2（15℃）	6.52%	√
Exp9	3（2:1）	3（23℃）	−6.34%	√
Exp10	4（1:2）	3（23℃）	−5.51%	√
Exp11	4（1:2）	1（0℃）		
Exp12	4（1:2）	2（15℃）	5.64%	√
Exp13	5（1:3）	3（23℃）	−4.95%	√
Exp14	5（1:3）	1（0℃）		
Exp15	5（1:3）	2（15℃）	5.10%	√
Exp16	6（1:4）	2（15℃）	4.51%	√
Exp17	6（1:4）	3（23℃）	−4.32%	√
Exp18	6（1:4）	1（0℃）		

Through the table, it could be drawn that when the moisture content is more than 30%, the error range of the moisture content is small, which is helpful for the measurement of moisture content of crude oil. In obtaining the samples, the range of the oil content of more than 70% should be avoided.

Network sample test

The improved BP network simulated annealing the samples after training to meet the requirements, the improved BP network sample need to be tested to see whether the moisture content of the crude oil has reduced and whether the measurement accuracy is improved.To this end, here are some of the test data, as shown in Table 2

Table 2 Network sample test data

Temperature	Oil/Water(volume)	Measured Moisture Content	Error compensation value of BP neural network algorithm	Actual Moisture Content
21	4:6	65.67%	63.40%	60.00%
21	4:8	71.46%	70.25%	66.67%
23	4:10	76.50%	73.68%	71.43%
24	4:12	80.42%	77.55%	75.00%

Through sample test, measurement error of the moisture content is relatively great: between 5% -7%; after improving neural network error compensation, the error range is between 3% -4%. Therefore, an improved simulated annealing BP network error compensation, to a certain extent can reduce errors and improve oil measurement accuracy.

Summary

The text describes the establishment of the crude oil measurement model based on an improved BP network, through orthogonal experimental design, network training sample are obtained and tested, test results show that the error of water content of crude oil has been reduced and the measurement accuracy has been improved comparing with that before error compensation of the improved BP network ,

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