Study on Temperature Prediction of Mine Tape Conveyor Reducer Based On PSO-BP

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Study on Temperature Prediction of Mine Tape Conveyor Reducer Based On PSO-BP

Yong Yang[a], Chenchen Cui*, Xiucai Guo[b], Qinsheng Wang, Zhiqi Ren

Xi'an University of Science and Technology, Xi'an 710054, China

*Corresponding author e-mail: 921096205@qq.com, [a]YONGY@XUST.EDU.CN, [b]guoxiucai@163.com

Abstract. Mining tape Conveyor is an indispensable part of the daily production of coal mines. In order to avoid the fault of mine tape conveyor reducer as far as possible, based on the characteristics of mine tape conveyor system, this paper uses particle swarm algorithm to optimize BP neural network to predict the temperature of the transmission of the belt conveyor. Fuzzy c mean clustering denoising is carried out on the temperature data containing noise in the transmission of tape conveyor, and the temperature data containing noise are identified and the anomaly points are corrected by the characteristic curve. On the basis of temperature data preprocessing, the temperature prediction method of PSO-BP neural network for tape conveyor transmission is proposed. The simulation results show that the temperature prediction model of PSO-BP Neural network has the advantages of higher prediction accuracy and shorter convergence time, and has strong application significance.

1. Introduction

Mining tape transporter is an important equipment in coal mine production and transportation, which belongs to the large-scale production machinery of reciprocating movement, has the characteristics of large inertia, large load and its change, fast running speed and wide range of speed regulation, and its running state is not only directly related to the normal production and production efficiency of mine, but also closely related to equipment and personal safety [1]. With the continuous expansion of coal mine production scale and the continuous extension of mining depth, the reliability and safety of tape conveyor have been put forward higher requirements, the importance of tape transport safety is becoming increasingly prominent. Whether the mining tape transporter can run stably and reliably plays a key role in the continuous safety production of coal mine underground, and is also the foundation of coal mine safety production.

Reducer is the power transmission component of mine hoist, is one of the most critical parts of hoist, and its dynamic and real-time monitoring is an important way to ensure the continuous operation, development and safety of workers ' life in coal enterprises [2]. At present, the commonly used condition monitoring technology mainly includes temperature monitoring, vibration monitoring and oil analysis and other technologies. Although these technical methods can determine the operating conditions of the predicted reducer to a certain extent, but all are abnormal or damaged in the reducer will be called to the police, its response is not timely and difficult to meet the needs of coal enterprises safe production.In recent years, scholars at home and abroad have put forward fault diagnosis models of various mining tape conveyors, such as mathematical model method, fuzzy neural network, expert diagnosis method, general BP neural Network and so on. In these fault diagnosis models, BP Neural network can carry out multi-layer feedforward, which is widely used in fault diagnosis system. However, BP neural network has the problem of easy to fall into the local minimum, too many training times lead to too slow convergence speed and so on [3]. On this basis, this chapter proposes a prediction algorithm based on particle swarm optimization bp neural network, analyzes the influence of the system temperature, establishes the prediction model of the parameters of the particle swarm optimization bp neural network, and improves the temperature change by this model to improve the safe operation reliability of the hoist.

2. Temperature data processing model of mine belt conveyor Reducer

The temperature curve of the belt conveyor reducer has two very important characteristics: smoothness and similarity. Smoothness means that there is generally no significant change between the points and points that make up the curve (except in special cases); similarity means that several crest moments of the curve should be essentially the same [4]. Therefore, we can use the fuzzy C mean clustering algorithm in data mining theory to extract the characteristic data from the data containing the noise, and use the clustering algorithm to separate the temperature data of the tape conveyor transmission containing the noise from the normal normal characteristic data, so as to realize the recognition of the noise data. The noise data processing model is shown in Figure 1.

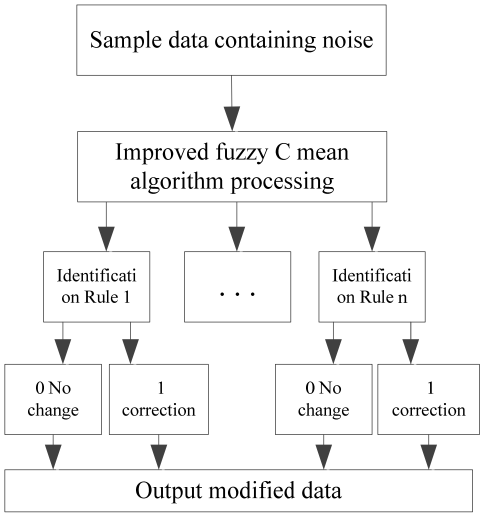

Figure 1. Noise Data processing Model

2.1. The denoising principle of fuzzy C mean algorithm

Fuzzy c mean clustering algorithm is a stepwise iterative data clustering algorithm which optimizes the objective function, which is iterated along the direction of the reduction of the objective function, which can determine the membership degree of each sample point to the classification center by improving the criterion function, so as to determine the category to which the sample belongs [5]. The implementation principle of fuzzy C mean clustering algorithm is as follows:

A sample set of the transmission temperature of the belt conveyor is $A = \{a_1, a_2, ...a_n\}$, where element a has a k characteristic, that is, $a_i = \{a_{i1}, a_{i2}, ...a_{ik}\}$.To divide A into class M ($2 \le m \le n$). It has an M clustering center, $cen = \{c_1, c_2, ...c_m\}$.Take d_{ij} as the European distance between sample a_i and cluster center c_j, recorded as:

$$d_{ij} = \left\| a_i - c_j \right\| = \sqrt{\sum_{i=1}^{n} (a_{ki} - c_{ij})^2} \tag{1}$$

The clustering objective functions are:

$$\min J_{IFCM}(A, U, Cen) = \sum_{i=1}^{n} \sum_{j=1}^{k} U_{ij}^{a} (d_{ij})^2 \tag{2}$$

and meet

$$\sum_{i=1}^{m} U_{ij} = 1 \tag{3}$$

In the formula, U_{ij}—Degree of membership of a sample in category B

a—Fuzzy weighted parameters $a \in [1, \infty)$.

Using Lagrange multiplier method and combining (3) formula to solve (2), the formulas of fuzzy feature matrix U and Cluster center CEN (4) and (5) can be obtained:

$$U_{ij} = \left(1 / (\sum_{j=1}^{m} (\frac{d_{ij}}{d_{ik}})^2) \right)^{\frac{-2}{a-1}} \tag{4}$$

$$Cen_j = \frac{\sum_{i=1}^{n} U_{ij}^{a} \times a_i}{\sum_{i=1}^{n} U_{ij}^{a}} \tag{5}$$

Clustering objective function to find a partial derivative of a, can prove that there is an extreme point in the partial derivative, so the a value corresponding to the point can be selected as the optimal fuzzy weighted parameter, such as formula (6):

$$a^* = \left\{ a \left| \frac{\partial}{\partial m} \left[\frac{\partial Ja(U, Cen)}{\partial m} \right] = 0 \right. \right\} \tag{6}$$

2.2. Basic steps of fuzzy C mean denoising algorithm

The basic steps of the fuzzy C mean algorithm are as follows:

STEP1: Set the radius of the enclosing ball to R, according to the density of the temperature data point of the belt conveyor transmission to set the threshold value of the number of data points in the surrounding ball is σ;

STEP2: Select a tape transporter transmission temperature data point a_j calculated to c_j as the center, R for the radius of the surrounding ball in the number of adjacent points N;

STEP3: Calculate the distance between point a_j and cluster center c_j in the surrounding ball d_{ij} ,b and set the threshold of σ , if it is $d_{ij} > \sigma$, then determine the data point a_j as the noise point, delete directly;

STEP4: If $a_j \le \sigma$, the data point a_j is considered to be the qualifying point, using the improved fuzzy C mean algorithm to cluster the surrounding ball where c_j is located, record the data in the cluster, and use the data of the clustering center as a substitute for all the data in the enclosing ball;

STEP5: Return steps Step2 determine the remaining points in turn.

2.3. Identification and correction of noise data

After the algorithm is processed, the temperature sample data of the transport tape transporter transmission will produce M clustering center, and the noise data will be located, and the temperature data sample set of the belt conveyor transmission $A = \{a_1, a_2, ...a_n\}$, in the case of 0 or too high temperature values at some point, and with less data, it can be calculated by calculating its moving average a_x , And a_x replaces the exception point data, the alternative value can be calculated by the mean of the first n (generally 10) number of positions at that time, such as formulas (7)

$$a_x = \frac{\sum_{i=x-10}^{x} a_i}{N} \tag{7}$$

The identified and modified temperature data of the belt conveyor transmission is $\overline{A}$

3. PSO-BP algorithm

Particle swarm optimization algorithm (particle Swarm OPTIMIZATION,PSO), proposed by Dr. Eberhart and Dr. Edy of Ke Neural network in the last century [6], is an intelligent group algorithm that draws on the foraging behavior of migratory birds. In PSO, it is assumed that the problem that needs to be optimized is the group of birds that are foraging, and each bird is a solution to the problem, which is called a particle, and the object searched by the flock is the optimal solution to the optimization problem. Each particle has its own speed and position, and the position represents an implicit solution to the optimization problem, which determines the distance and direction of the particle's flight, and the adaptive value is determined by the optimized function. On the one hand, the particle has self-nature, can determine the direction and speed of its own flight according to the prior prior knowledge, on the other hand, it is social, can adjust its flight speed and direction by analyzing the flight situation of the surrounding particles, and constantly find the balance between the individual and the group. Immediately thereafter, all particles search within the solution space to remember and follow the current optimal particles. In this process, each iteration is not entirely random, if a better solution is found, the solution will be used as the basis to find the next better solution.

The PSO is initialized into a set of random solutions [7], that is, a group of random particles, during each iteration, the particles update themselves by tracking the two optimal solutions they have searched for themselves and the entire population, which are called individual extremum P_{ibest} and global extremum g_{best} , respectively. When searching by using global extremum, the search speed is fast and it is easy to fall into local optimization. In the study of temperature prediction, this paper combines the characteristics of global extremum and individual extremum, and continuously updates the iterative process, and finally outputs the optimal solution of the algorithm. PSO is an algorithm attached to probabilistic search, and the process of Group search optimization makes the PSO algorithm have the following advantages:

(1) The optimization time is short, will not go through the cross variation similar to the genetic algorithm, mainly through the particle velocity and position of the iteration to complete, the overall realization is simple, the convergence speed is fast;

(2) There is a strong robustness, in the process of optimization of all particles are not subject to uniform instructions, so an individual will not affect the overall situation;

(3) There is no direct communication between groups to ensure that the system has the scalability of optimization; (4) Particles have memory, the best position of their own can be recorded and transmitted to other particles.

Because BP neural network has the problem of easy to fall into local extremum point and slow convergence speed, the particle swarm optimization algorithm using Group intelligent optimization algorithm to optimize BP neural network PSO-BP Neural Network algorithm steps are as follows:

STEP1: Initializes the speed and position of each particle.

STEP2: Calculates the adaptive value of each particle.

STEP3: Find the optimal value of individual and group of each particle.

STEP4: Updates the speed and position of particles. If the pre-set maximum number of iterations is reached during the optimization process, stop and output the optimal solution at this time; otherwise, turn to the second step to continue the loop execution.

STEP5: Gets the optimal weights and thresholds and assigns them to the BP network.

STEP6: Calculate the error of BP network model, if the error does not meet the requirements, then continue to update the weight and threshold of the network until the conditions are met. The flow chart of the PSO Optimization BP neural network algorithm is shown in Figure 2:

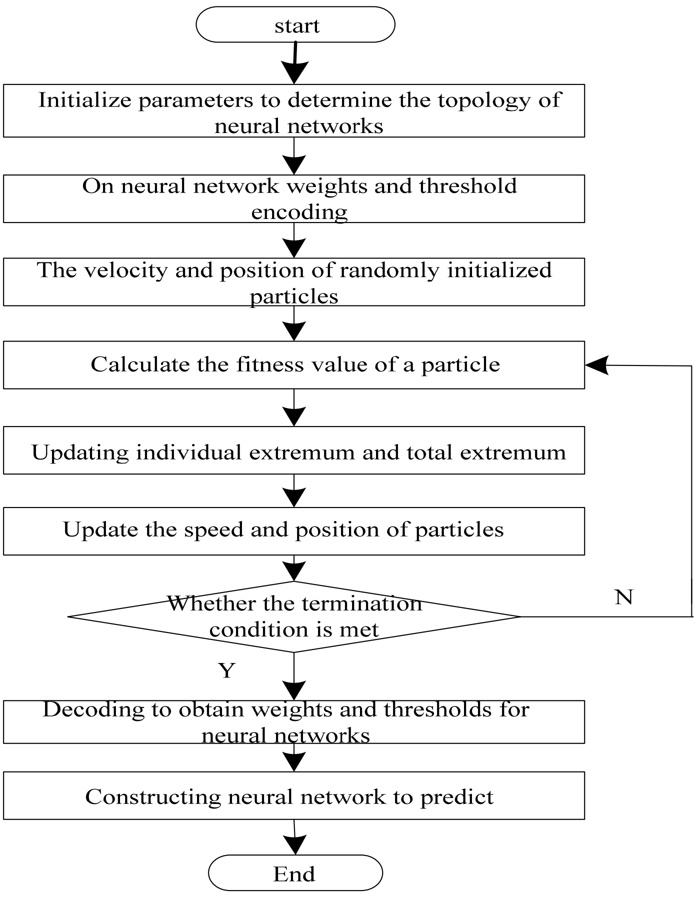

Figure 2. PSO-BP Neural Network algorithm flowchart

4. Experimental Simulation

In order to realize the accurate prediction of reducer temperature. selecting the temperature data of 120 different moments of the bearing temperature of the reducer , using the first 90 data in the data as the training sample, The temperature data for the remaining 30 transmissions are used as validation samples. The temperature sample data of 90 sets of tape transporter transmission were improved by improving fuzzy C mean denoising. On this basis, the results of this experiment are compared with those of BP neural Network algorithm by simulation experiment, and the results of simulation comparison are shown in Figure 3.

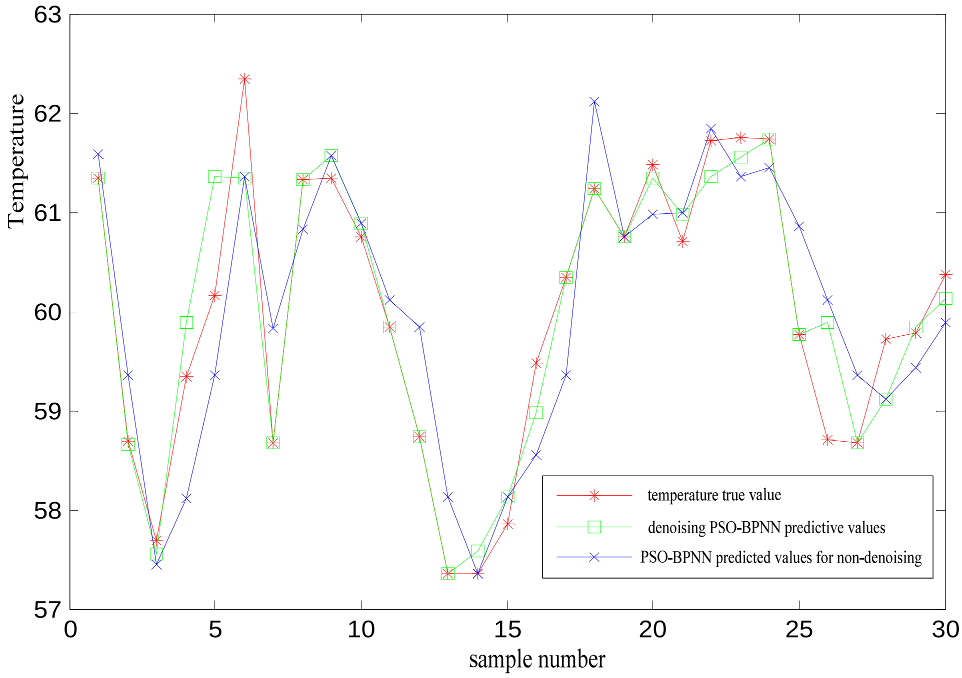

Figure 3. Comparison diagram of prediction effect between PSO-BP and BP algorithm

The horizontal coordinates in Figure 3 are sample numbers, and the longitudinal coordinates are the transmission temperature of the tape conveyor. It can be seen from the graph that in the process of prediction, the predictive value of BP neural network algorithm deviates from the actual value is more serious, while the prediction effect of PSO-BP Neural network algorithm is better, and the overall fitting of the predicted value and the actual value is better.

Table 1 .Comparison of relative error between BP and PSO-BP (%)

δ	5	10	15	20	25	30
BP Neural Network prediction	14	18	12	9	17	9
PSO-BP Neural Network prediction	10	9	6	5	6	3

As can be seen from table 1, the temperature corresponds to the maximum, minimum and average relative errors predicted by the unoptimized BP Neural network algorithm are 20%, 9% and 14.23% respectively, while the temperature values predicted by the PSO optimized BP neural network model are close to the actual value, and the maximum relative error is 11%. The minimum relative error is 2.23%, the average relative error is 5.8%, the relative error is obviously reduced, the prediction is more accurate, and the optimization effect is obvious.

5. Conclusion

Aiming at the phenomenon that the temperature data of the transmission of the tape transporter contains noise, the fuzzy C mean clustering denoising is carried out on the temperature data of the transmission of the tape transporter, the anomaly points are identified, and the noise-containing data is identified and corrected by using the characteristic curve. On the basis of temperature data processing, the temperature prediction method of PSO-BP neural network for tape conveyor transmission is put forward and the algorithm is verified in the simulation software. The simulation results show that the temperature prediction model of PSO-BP Neural network has the advantages of higher prediction accuracy and shorter convergence time, and has strong application significance.

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