Research on BP model optimization of PSO algorithm based on Computational Mathematics

Pin Wang¹, Yuefei Gao²,*

¹School of Economics, Guangzhou College of Commerce, Guangzhou 511363 China
²Guangxi College of Education, Nanning 530023, Guangxi, China

*Corresponding author e-mail: 850506135@qq.com

Abstract. Construction of the quality and safety evaluation model for dairy products is significant to ensure food safety for people. In the case that there is a big error in the BP neural network quality and safety evaluation model for dairy products, this paper put forward the optimization method based on the PSO algorithm to reduce the output error of the BP neural network evaluation model through optimizing the weights and thresholds of BP neural network. By simulation of optimizing the BP evaluation model through specific data, experiments showed that compared with the standard BP evaluation model and standard BP evaluation, the optimized BP evaluation model is greatly improved in output error.

Keywords: Dairy Products; BP Neural Network; PSO Algorithm; Evaluation Model; Quality and Safety.

1. Introduction

With the improvement of living quality in China, dairy products have become an important component in the indispensable household food structure, and dairy quality and safety problems are getting more and more closely with people's health. On the one hand, consumers' demand for dairy products is on the rise. In the face of frequent safety events, the quality and safety of dairy products has become the focus of attention. As the quality and safety of dairy products is closely linked with people's livelihood, improvement of the quality and safety of dairy products has become an important issue to be solved in China. In recent years, many scholars have used different methods to apply economics, management, public administration and other relevant theories to do a lot of research on improving the quality of dairy products from different angles, which has achieved gratifying results [1,2,5]. Construction of the quality and safety evaluation model for dairy products is one of the important methods to improve the quality of dairy products by statistical theory, modern information technology and other means. There are a variety of programs and methods to build the quality evaluation model, of which, the evaluation model built based on the average method and regression analysis method of the traditional statistics [3] is one of the traditional and successful approaches. Although it is a mature approach in theory and practice, this approach brings more human subjective factors and its predicted results cannot meet the needs of social development. The BP neural network is a forward-propagating neural network based on error back-propagation algorithm. In recent years, it got a good effect during application in many fields [6]. Construction of the BP neural network quality and safety evaluation model for dairy products is a better
option. With the Wondersun Dairy as an example, by building relevant data table, reference [4] selected 19 relevant options as the evaluation index and used the BP neural network to build the evaluation model (hereinafter referred to as “the standard BP evaluation model”), which got good test results. However, due to the presence of large errors and other deficiencies in construction of the BP neural network evaluation model, the data error of predicted output of BP neural network evaluation model is large. Optimization of the evaluation model or prediction model based on BP neural network with the intelligent optimization algorithm is one of the effective ways to reduce large errors in network output value. This paper put forward to use the PSO optimization algorithm to improve the BP neural network quality and safety evaluation model for dairy products (hereinafter referred to as “the PSO-BP evaluation model”) to optimize the weights and thresholds of the trained BP neural network model with the PSO algorithm, thereby reducing the network output error and improving the network stability. Experiments show that in the MATLAB2010a environment, the evaluation model optimized with the PSO algorithm is greatly improved in output error.

2. The standard BP neural network quality and safety evaluation model for dairy products and its problems

BP (Back Propagation) neural network was proposed by a group of scientists led by the Rumelhart and Mc Celland in 1986. It is a widely used neural network model. Its topological structure includes the input layer, the hidden layer and the output layer. The BP neural network structure can contain multiple hidden layers. However, to save resources for program running, typically, single hidden layer, i.e., single hidden layer BP network structure, will be selected. In practical applications, this simple three-layer BP network structure has been universally recognized. Its rational structure has better network stability and smaller error in predicted output.

Reference [6] uses the single hidden layer (i.e. three-layer network structure) BP neural network structure to build the quality and safety evaluation model for dairy products, a typical traditional BP network structure. Combined with practical situation, it first determined that the quality and safety of dairy products was mainly associated with 19 quality indicators, that is to say, 19 quality indicators determined the quality of dairy products. In BP network model design, the network input n = 19, output k = 1. According to the relevant formula, the number of hidden layer m is determined within the range of integer between 4 and 14. Through program simulation, through comparison with all the value range of m, it is obtained that m=8 is the best value. Therefore, the network structure is the 19-8-1 structure. However, due to the internal reasons of the BP network structure, there is a large error in predicated output of the evaluation model. To reduce network prediction error and improve the network prediction accuracy, this paper used the PSO algorithm to optimize the BP neural network quality and safety evaluation model for dairy products and verify the effectiveness of PSO algorithm through computer simulation.

The PSO algorithm and optimization of the BP neural network quality and safety evaluation model for dairy products

2.1. The main processes of the PSO algorithm are as follows:
Step1: randomly initialize the population;
Step2: calculate the fitness of individual particles;
Step3: update the most optimal group and individual according to the particle fitness;
Step4: update the speed and position of each particle;
Step5: determine whether the evolution is ended. If not, return to Step2.

2.1.1. Use the PSO algorithm to optimize the BP neural network quality and safety evaluation model for dairy products. The process of PSO algorithm optimization is to optimize the matrix of the BP neural network weights.

Firstly, determine the particle dimension of the PSO algorithm. Rank the factors of the weight and threshold matrix of BP network in accordance with the designed sequence to form a D-dimensional row
vector and the coordinate of the D-dimensional spatial points (particle position), thereby building the one-one mapping between BP network weight matrix and D-dimensional space, and mark it as $F$.

Secondly, determine the fitness function of the PSO algorithm.

This paper used the sum of absolute values of the BP neural network output value error as the fitness function value and use the reverse distortion of $F$ as the weight and threshold matrix of the BP network prediction model, used the testing data for prediction and calculated the sum of its absolute value of output error to obtain the fitness value of particles. The smaller the fitness value is, the more superior the particles will be.

So far, the two elements of the PSO-BP model have been identified.

The process of using the PSO algorithm to optimize the BP neural network quality and safety evaluation model for dairy products is shown in the following figure.

**Figure 1.** The algorithm flow chart of the PSO-BP

3. Simulation experimen

3.1. T Simulation data and environment

To verify the effectiveness of PSO algorithm in optimizing the BP neural network evaluation model and make a longitudinal comparison, the simulation process used the data in the data table in Appendix II of reference [6] (a total of 40 sets) as the training data and testing data. Among them, 32 sets of data numbered from 1 to 32 is the training data, of which, the last column is the expected value, and 8 sets of data numbered from 33 to 40 is the testing data, of which, the last column is the actual value. Simulation was conducted under the Matalab2010a environment.
3.2. simulation results and analysis
The 1st to 32nd lines within the above data table were used to form the 32 × 19 matrix A as the training sample. The 33rd to 40th lines were used to form the 8 × 19 matrix T as the testing sample. The simulation was conducted in the BP structure and PSO-BP evaluation model respectively, of which, the BP network structure was generated with the toolkit standard function newff() coming with MATLAB2010a. The parameters of the PSO-BP evaluation model are as follows.
Since the original standard BP evaluation model uses the 19-8-1 architecture, namely there are 19 nodes in the input layer, there are 8 nodes in the output layer, there is 1 node in the output layer, there is a total of 160 (19*8+8*11) weights and 9 (8+1) thresholds, and the total number of weights and thresholds are 169 (160+9). The sequence formed by all the weights and thresholds of the BP model is corresponding to the coordinates of a point in the D-dimensional space (D = 169). Therefore, the particle dimension of the PSO algorithm D = 169; 1.4900 is taken as the cognitive system c1; 1.4900 is taken as the social factor c2. To save operational costs, 1.0 is taken as the inertia factor. The maximum iterative algebra maxgen = 200.
The following results were obtained through comparison of the testing value and the expected value in the data table.

| Actual value | Standard BP | PSO-BP | Standard BP Error Rate (%) | PSO-BP Error Rate (%) |
|--------------|-------------|-------|---------------------------|-----------------------|
| 8            | 9.0568      | 8.4022| 13.21%                    | 5.03%                 |
| 9            | 9.9749      | 9.3056| 10.83%                    | 3.40%                 |
| 6            | 6.1600      | 5.9523| 2.67%                     | -0.79%                |
| 3            | 2.9243      | 3.0588| -2.52%                    | 1.96%                 |
| 1            | 1.0171      | 1.0125| 1.71%                     | 1.25%                 |
| 7            | 7.0591      | 7.0556| 0.84%                     | 0.79%                 |
| 4            | 3.8890      | 4.0478| -2.78%                    | 1.19%                 |
| 5            | 5.0481      | 5.0450| 0.96%                     | 0.90%                 |

From the test results, it can be seen that: among 8 sets of testing data, the output error of each set of testing data of the PSO-BP evaluation model is smaller than that of the standard BP evaluation model, which indicates that the PSO-BP BP evaluation model has better evaluation performance and more accurate evaluation results in error performance than the standard BP evaluation model.
4. Conclusion
In the face of the big error in the standard BP neural network evaluation model, the PSO algorithm was used to optimize the BP neural network quality and safety evaluation model for dairy products and the actual data was used in the evaluation model to obtain the error between the output value and the actual value. Comparison of the error and the output error of the standard BP evaluation model [Liu, 2014] showed that: the error rate of the BP evaluation model optimized by the PSO algorithm was lower than that of the standard BP evaluation model, the performance and error rate of the optimized BP evaluation model had been improved and the output accuracy had been significantly improved.

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