Study on Logistics Demand Forecasting Based on Improved Adaptive Genetic Algorithm and BP Neural Network

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Abstract: Logistics demand forecasting is the basis of making logistics development policy. In order to improve the accuracy of logistics demand forecasting, an improved adaptive genetic algorithm (IAGA) was designed at first. Then a logistics forecasting method was established with improved adaptive genetic algorithm and BP neural network. It made the initial weights and threshold of BP neural network optimized by GA .Further, the IAGABP neural network model was constructed to forecast the logistics demand. The empirical results show that, the IAGABP algorithm can predict logistics demand more accurately.

Keywords: Adaptive genetic algorithm; BP neural network; Logistics demand forecasting

1. Introduction

Logistics demand forecasting is the basic of formulating logistics policies and optimizing the allocation of logistics resources [1]. In particular, with the rapid increasing of logistics demand in recently years, the accuracy of logistics demand forecasting is significant for development of logistics industry.

In order to improve the accuracy of logistics demand forecasting, the scholars have carried on the research to the logistics demand forecasting method. The BP neural network algorithm is widely used, but it has some disadvantages, such as, the network structure is hard to choose and the algorithm is easy to fall into local optimal solution [2]. In this regard, most scholars used intelligent algorithms to improve the BP neural network algorithm, such as [3]-[5]. The adaptive genetic algorithm is used mostly because it has larger search space and doesn't need to adjust the crossover probability and mutation probability. In fact, the traditional adaptive genetic algorithm still may fall into the local optimal solution in the initial stage of evolution, so the forecasting precision of the above literatures is still to be improved.

2. Improved Adaptive Genetic Algori-thm

2.1. Adaptive genetic algorithm

In the standard genetic algorithm (GA), crossover operator and mutation operator are the important ways to generate new individuals and new genes. If the crossing probability is too large, the excellent individuals in the population will be destroyed, and the small probability will slow down the evolution. At the same time, if the mutation probability is too large, the algorithm will degenerate into the random search operator, and the small mutation probability will lead that GA is difficult to produce new genes and easy to fall into the local optimal solution. Therefore, the crossover probability and the mutation probability are important for the performance of GA. In the GA, the crossover probability and mutation probability are determined by a lot of experiments. Aiming at it, paper [6] proposed the adaptive genetic algorithm (AGA), whose crossover probability and mutation probability would change by itself. As formula (1) and (2) shown, through the resetting the crossover probabilities and mutation probabilities, the individuals, whose fitness values are lower than the average fitness value of the population, will participate in the crossover and mutation with larger probabilities. It will produce the new individuals and genes. The individuals, whose fitness values are higher than the average fitness of the population, will participate in the crossover and mutation with smaller probabilities. It will protect the outstanding individuals. The AGA improves the shortcoming of GA, which GA is easy to be trapped in local optimum due to the selection of the crossover and mutation probabilities. However, there are also some problems in the initial stage of AGA evolution. In the initial stage of population evolution, the population’s average fitness value and excellent individuals’ fitness values are not very different, it leads that the crossover and mutation probabilities of excellent individuals are almost zero. And the good individuals at the early stage of the algorithm are not usually the best individuals, so the AGA is easy to fall into local optimal solution as well.

$$P_c = \begin{cases} K_1 \dfrac{f_{\max} - f'}{f_{\max} - f_{avg}} & f' \ge f_{avg} \\ K_3 & f' < f_{avg} \end{cases} \qquad (1)$$

$$P_m = \begin{cases} K_2 \dfrac{f_{max} - f'}{f_{max} - f_{avg}} & f' \geq f_{avg} \\ K_4 & f' < f_{avg} \end{cases} \quad (2)$$

f_{max} is the maximum fitness value in the population, f_{avg} is the average fitness value of population, f' is the larger fitness values in two individuals.

2.2. Improved adaptive genetic algorithm

In order to improve the performance of the algorithm, in the early stage of the algorithm, the crossover and mutation probabilities of the fine individuals must be maintained at a certain level. From the aspect of the algorithm evolutionary process, the crossover probability and mutation probability should take great values at the early stage of the algorithm. It will help to expand algorithm search ranges and accelerated the generation of new individuals and genes. In the latter stages of the algorithm, in order to protect the good individual, crossover probability and mutation probability should be taken smaller values.

In this paper, an improved adaptive genetic algorithm was proposed. The algorithm can not only make excellent individuals to maintain a certain crossover probability and mutation probability. At the same time, the probabilities of crossover and mutation were adjusted according to population evolution algebra and individuals' fitness values. The crossover and mutation probabilities of IAGA are shown in type (3) and (4)

$$P_c = \begin{cases} F(t)\,[K_0 + (K_1 - K_0)\dfrac{f_{max} - f'}{f_{max} - f_{avg}}] & f' \geq f_{avg} \\ K_1 & f' < f_{avg} \end{cases} \quad (3)$$

$$P_m = \begin{cases} F(t)\,[K_2 + (K_3 - K_2)\dfrac{f_{max} - f'}{f_{max} - f_{avg}}] & f' \geq f_{avg} \\ K_3 & f' < f_{avg} \end{cases} \quad (4)$$

$F(t)$ is the degradation factor, $F(t) = l\,e^{-b(\frac{t}{T})a}$, t is the current evolutionary algebra, T is the total evolutionary algebra.

Through the formula (3) and (4), we can know that the degradation factor doesn't work obviously in the initial stage of the algorithm evolution, and $F(t) \approx 1$.The dynamic range of the crossover probability and mutation probability of the excellent individuals, whose fitness values are higher than the average fitness of the population ,are $K_0 \sim K_1$ and $K_2 \sim K_3$. The lowest crossover probabilities and mutation probabilities of the excellent individuals are respectively K_0 and K_2.So the fine individuals can keep the high crossover and mutation probabilities in the early stage, and avoid the local optimal solution. In the middle and late stages of the algorithm evolution, the degradation factor rapidly becomes small, so that the individuals' crossover and mutation probabilities become small, then the outstanding individuals are protected, and the performance of the algorithm is improved.

3. IAGABP Logistics Demand Foreca-sting Algorithm

IAGABP logistics demand forecasting algorithm is divided into four steps. First, optimizing the initial weights and threshold of BP neural network by IAGA algorithm; Second, structuring the best BP neural network using the optimal weights and threshold; Third, using training set to train the BP neural network, and constantly adjusting the weights and threshold until the training schedule is reached; Fourth, making the logistics demand prediction through the trained neural network. IAGABP algorithm is divided into two parts, IAGA algorithm and BP neural network algorithm.

3.1. IAGA algorithm

(1) Individual coding. Real number coding is used, and each individual's coding is composed of four parts, named the weights connecting the input layer and hidden layer, the hidden layer and output layer, the threshold of the hidden layer and output layer.

(2) Fitness function. The fitness function value is the absolute values sum of error between forecast and actual values.

(3) Selection operator. The selection operator is roulette wheel selection operator. Taking the fitness of individuals in the population as the basis of dividing the bet disk, and making the probabilities of selecting the good individual are higher.

(4) Crossover operator. As the following formulas, the arithmetic crossover operator is adopted in this paper.

$$x'_A = a\,x_A + (1-a)x_B \quad (5)$$

$$x'_B = (1-a)x_A + a\,x_B \quad (6)$$

x_A, x_B are the parent individuals A and B, x'_A, x'_B are the chromosomes formed after crossing, a is a random number in (0,1).

(5) Mutation operator. The single point mutation operator is adopted. For each individual, a random point g in (0, 1) is generated, and the mutation operation is carried out at the point as follow.

$$X_{A,j} = a_j + g\,(b_j - a_j) \quad j = 1, 2, \ldots, k \quad (7)$$

3.2. BP neural network algorithm

BP neural network algorithm adopts the traditional BP neural network method. It is divided into three steps.

(1) Optimizing initial weights and threshold of the BP neural network. Randomly generating BP neural network initial weights and thresholds, then using the IAGA algorithm to optimize them.

(2) Establishing the IAGABP neural network. Taking the optimal weights and threshold as the neural network parameters, then using the training data to adjust the network parameters until the results meet the solving precision, finally establishing IAGABP neural network.
(3) Logistics demand forecasting. Forecasting the logistics demand of the test concentration by the final IAGABP neural network.

4 Forecasting Example

In order to validate the forecasting effect of IAGABP logistics demand forecasting method. The logistics demand related data of Chongqing city in literature [7] were taken as the sample data, which quantity of shipments was output indicators, and GDP was input indicator. The first 8 groups were training data, and the other 5 were the test data. The sample was tested by standard BP neural network prediction method, the genetic BP neural network prediction method (GABP), adaptive genetic BP neural network prediction method (AGABP), and the IAGABP algorithm. Results are shown in Table 1 below.

Table 1. Forecast error of test set (unit :%)

Method	2005	2006	2007	2008	2009
BP	0.871	0.701	0.693	-0.598	0.603
GABP	-0.135	0.390	-0.284	0.634	0．437
AGABP	-0.201	0.193	0．243	-0.391	-0.236
IAGABP	0.061	0.042	-0.054	-0.042	0.085

As table 1 show, the prediction accuracy of BP neural network method is the worst, and the prediction accuracy of GABP and AGABP is better. It shows that the choice of initial weights and threshold of the BP neural network have a certain influence on the prediction accuracy, and the optimization to the weights and threshold of BP neural network helps to improve the accuracy of the algorithm. The improvement of IAGABP algorithm in the forecast precision is obvious, and it because the IAGA algorithm proposed in this paper overcomes the disadvantages of the traditional genetic algorithm and the adaptive genetic algorithm.

5. Conclusions

Due to the limitations of the adaptive genetic algorithm, the forecasting accuracy of the existing BP neural network prediction algorithm based on AGA needs to be improved. Aiming at the problem, this paper presented improved adaptive genetic algorithm (IAGA), then optimized the initial weights and threshold of BP neural network by IAGA, finally constructed BP neural network prediction model based on IAGA. Through the example, the proposed forecasting algorithm has higher forecast precision.

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