Network Based on Improved Genetic Algorithms

Qi Anzhi

Liaoning Jianzhu Vocational College, Liaoyang, Liaoning, China

Keywords: Improved genetic algorithm; BP neural network; Neuron

Abstract: BP Neural Network is a kind of non-linear system which simulates brain information processing algorithm. It has strong distributed information storage, parallel processing and adaptive learning ability. It is a multi-layer feed forward network trained by error back propagation algorithm. Combining it with genetic algorithm, a learning and training approach with good global optimization search and local time-frequency characteristics can be obtained. In this paper, the crossover rate of genetic algorithm is improved, and the efficiency of the algorithm is improved. At the same time, in order to solve the problem that the initial population is far away from the optimal individual, the convergence speed is slow and it is easy to fall into the local minimum. The information gain of the feature is used as the degree of discrimination of each feature to the category. On this basis, it is used to optimize the BP neural network input layer neuron screening method. The experimental results show that the efficiency of the traditional method is significantly improved.

1. Introduction

Artificial neural network (ANN) is an information processing system which simulates the structure and intelligent behavior of human brain based on the understanding of its structure and operation mechanism. It is a distributed parallel information processing system which simulates the processing behavior of brain neural network and interconnects a large number of neurons based on the achievements of modern neuroscience research [1]. Because genetic algorithm searches in many regions of solution space, it can jump out of local optimum with a relatively high probability, so it can find the global optimum solution. Among them, BP algorithm plays an important role in neural networks, mainly used in the fields of prediction, fuzzy recognition, automatic control and image processing [2]. BP neural network algorithm has strong nonlinear mapping and self-learning ability, and has been widely used in pattern recognition, classification and image processing. Has a strong nonlinear function approximation, self-learning and fault tolerance. It has its own unique features in complex control problems such as industrial process control, and is very suiTable for modeling and solving complex nonlinear problems.

Although some scholars have proposed a number of improved algorithms, the inherent inherent defects of BP networks have not been well compensated, and many algorithms are improving the shortcomings of one of them, and the application scope is limited [3]. Therefore, this paper introduces the genetic algorithm into the BP network and optimizes it. The sample space is preprocessed with a rough set, and the reduced sample space is obtained and then input into the neural network training. This method combines genetic algorithm with single neuron control based on improved fitness function, and avoids trapping local minima with the global optimization ability of genetic algorithm. A neural network controller based on improved genetic algorithm is designed. The simulation results show that the proposed control scheme can make the system converge quickly, have good real-time effect and strong anti-jamming ability.

2. Methodology

Genetic algorithm is a probabilistic stochastic search optimization algorithm. It simulates natural evolution phenomena such as natural selection, hybridization and mutation of biological population, and then evolves into excellent individuals. In the process of feature selection, it can be used as a

search strategy of feature subset. BP learning algorithm consists of forward propagation and backward propagation [4]. Forward propagation refers to the transfer of input signals from the input layer to the output layer through the hidden layer. If the output layer obtains the desired output, the learning algorithm ends; otherwise, it turns back to propagation. BP neural network is essentially an unconstrained non-linear optimization calculation process based on gradient descent method. When the network structure is large, it not only takes a long time to calculate, but also can not get the global optimal result because it is easy to limit to local minimum. In practical applications, most of the neural network models use BP neural networks and their variations [5]. Due to the dependence and association between conditional attributes and decision attributes, not all conditional attributes are necessary for decision attributes, which leads to the problem of attribute reduction. It can learn and store a large number of input-output mode mapping relationships without the need to reveal the mathematical equations describing this mapping relationship [6]. The improved fitness function not only ensures that the fitness function is non-negative, but also allows the fitness function value to change with the individual changes in the input space, improving the individual's competitiveness.

The purpose of genetic algorithm optimization BP network in this paper is to make the structure of the network the most simplified and the error of the network reaches the minimum based on the accuracy requirements. Therefore, the fitness function chosen is:

$$f = \frac{1}{E} \tag{1}$$

$$E = \frac{1}{2}\sum_{p=1}^{m}\ \sum_{j=1}^{n}(d_{pj} - y_{pj})^{2} \tag{2}$$

Where E is the global error of the network; m is the number of training samples; n is the number of output layer units; p_{jd} is the expected output value; p_{jy} is the actual output value.

Coding is one of the basic work in genetic algorithms. The more intuitive and conventional encoding is binary encoding, also known as conventional encoding. Other floating-point encoding, integer or dictionary sorting encoding, etc. are called unconventional encoding. The reason is that the binary operator's crossover operator and mutation operator are very simple. The genetic algorithm has its own shortcomings in the commonly used binary coding. Only one bit of the two codes with different or identical codes is used. When the single point crossing is adopted, the crossover result is the same regardless of the position of the intersection selection [7]. The latter model of the algorithm concentrates around the individuals with higher fitness. If the crossover rate and mutation rate are larger, the good individuals in the population will be easily destroyed. From the output layer to the input layer, the output errors of neurons in each layer are calculated layer by layer, and the weight threshold is adjusted along the negative gradient direction of the error, so that the modified final output can approach the expected value. In this case, the approximate solution of the optimal solution of weight and threshold is obtained after individual decoding [8]. On this basis, BP algorithm is used for local optimization to find the optimal weights and thresholds of the network. If the expected output value is not obtained in the output layer, the difference between the actual output and the expected output (i.e. the error) is calculated recursively layer by layer, and the weight is modified by gradient descent method to minimize the total error function.

After the training samples are input into BP network, the output of the system is predicted, and the sum of absolute error between the actual output and the expected output is taken as the individual fitness value.

$$F = k\left(\sum_{i=1}^{n} abs(y_i - o_i)\right) \tag{3}$$

Where n is the number of network output contacts; yi is the expected output of the ith node of the BP network; oi is the predicted output of the ith node; k is the coefficient.

When the cumulative probability is greater than or equal to the generated random number, the individual to be pointed at is selected, so that the iteration number is satisfied. The selected probability formula is:

$$P_i = \frac{(k / F_i)}{\sum_{i}^{N} (k / F)} \tag{4}$$

The cumulative probability is:

$$cumul_i = cumul_{i-1} + p_i \tag{5}$$

In the formula, Fi is the fitness value of the individual i. Since the fitness value is as small as possible, the fitness value is reciprocated before the individual is selected; k is the coefficient; N is the number of individual populations.

Since the individual uses real coding, the crossover operation uses a real single point crossing method. When the crossover probability is satisfied, the cross-operation algorithm of the r-th chromosome S and the l-th chromosome j at the n-bit is as follows:

$$S_{\mathrm{j}} = \frac{1}{\sum_{i=1}^{n} (S_r)}, (0 < (S_{\mathrm{j}}) \le 1) \tag{6}$$

The single neuron control method based on improved genetic algorithm has a good global optimization ability, and pursues the global rationality of the problem solution in the whole search process. This improved algorithm enables the group to reduce the probability of destruction of the better mode and improve the algorithm search efficiency in the early stage of evolution. Since the topological structure in the real-coded genotype space is consistent with the topological structure of its phenotype space, it is easy to draw good techniques from traditional optimization methods to form effective genetic operators. The initial population is binary coded. The length of the binary code is determined by the accuracy of the specific requirements, and the number of iterations is set. Real number encoding is carried out directly in the form of solution space, which has clear meaning and can greatly shorten the string length. The genetic operation eliminates encoding and decoding operations and reduces the computational complexity of genetic algorithm. However, because BP neural network carries out single-point search, its global search ability is not good. The random setting of initial weight threshold makes the algorithm blind. In addition, to a certain extent, the neural network can filter the random noisea brought by the sampling process of training samples, while the rough set is very sensitive to noise. The simulation results show that the improved algorithm has better convergence speed and error accuracy than the standard BP algorithm without increasing the amount of computation and storage.

3. Result Analysis and Discussion

The genetic algorithm uses the way of population evolution to code the solution of optimization problem in some form and generate individuals. Because the genetic single neuron control algorithm based on improved fitness function is a method combining genetic algorithm and BP neural network, it not only has better global search ability of genetic algorithm, but also has strong approximation ability of neural network to non-linearity. In the case of small population size, after several iterations, the system has basically reached a sTable state, meeting the accuracy requirements, indicating that the improved genetic algorithm has a fast convergence speed. In addition, in order to ensure that the fitness is not negative, an additional member can be added, that is, the target value. Target values are not constrained by positive and negative constraints, it only needs to ensure that excellent individuals have higher target values. When the calculated body fitness is lower than the average fitness value, the individual has a higher probability of crossover and mutation, and the individual is eliminated. The neural network module further includes two

parts: a neural network and a sub-genetic algorithm. A nested computational structure is adopted, and the primary genetic algorithm corrects the initial weight threshold and the number of hidden layer neurons of the BP network at the program entry. The smaller the absolute value of the error, the better the network prediction ability. However, in genetic algorithms, the reciprocal is usually taken as the fitness value. The greater the fitness value, the better the prediction ability.

Figure 1 shows the structure of a three-layer BP neural network. It consists of input, output, and hidden layers; the number of input and output nodes is sum; the hidden node is set to two input nodes. Using sigmoid colon function as activation function, the output of each input sample is calculated, and the minimum mean square of output is taken as optimization criterion. When the result satisfies the minimum mean square error, the weights and thresholds are the best.

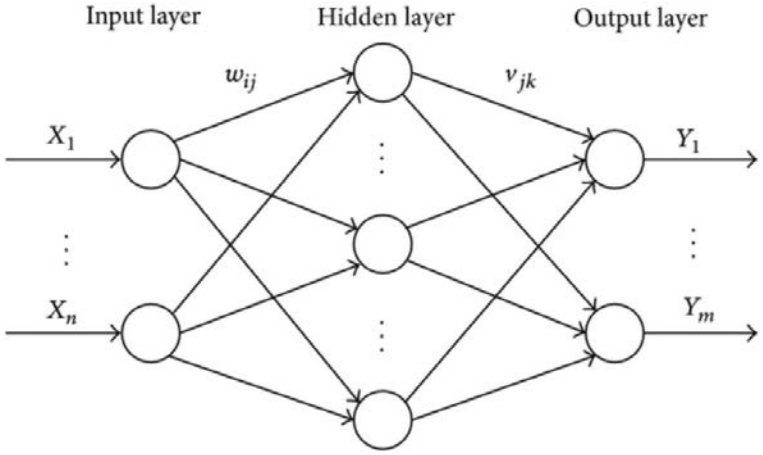

Fig.1. Structure of three-layer BP neural network

Since the individual control genes are binary coded, the parameter genes are encoded by real numbers, so different crossover operators are required for the control genes and the parameter genes. Each individual in the initial population tends to randomly select features with a number of features approximately equal to half the total number of features, and the initial population's fitness is generally not too high, thus slowing the evolution of the population. It can be seen that in the adaptive genetic algorithm, the minimum crossover rate and the minimum variability are both 0, and the maximum crossover rate and the maximum variability are also fixed values. In addition, the classical genetic algorithm can be improved by replacing the worst fitness individuals in the current population with the best individuals in the current population after crossover and mutation. Two individuals are randomly selected in the population, and a crossing point is randomly generated in the individual control gene string. The control gene substrings of two individuals after the crossing point are interchanged as a whole. In order to obtain satisfactory dynamic characteristics of the transition process, the time integral of the absolute error value is used as the objective function for the selection of the parameters of the neural network. Therefore, in order to compare two individuals who are not in the same generation of population, we must compare their target values, but not their fitness. This is why I add the target values as additional members of individuals when designing gene individuals.

In the feature selection method based on genetic algorithm, the most time-consuming step is the calculation of the target value. If the calculation speed of the target value is not optimized, the feature selection process will become infeasible for a slightly larger sample because of the time problem. BP neural network has high non-linear mapping ability and can approximate the non-linear function with arbitrary precision, so it is more suiTable for the modeling of some complex problems. In the vicinity of average fitness, the change of crossover rate and variation rate of individuals is smoothed, which avoids the large difference of crossover rate and variation rate between individuals near average fitness. In the BP network training process, according to the minimum square of the training error, the fitness value is selected, the crossover and the mutation operator are used to globally optimize the weight and threshold of the BP network as the initial

value of the network structure. Therefore, a local optimization strategy is used here to generate new individuals. The first few individuals with the greatest fitness in the parent are selected, and several random searches are performed within the neighborhood of each individual to obtain several new individuals. If you look up an individual with the same gene sequence in the Table, copy the target value of the individual directly to it, eliminating the complicated steps of calculating the target value, which can greatly speed up the genetic evolution. This avoids the phenomenon of stagnation in the later stages of evolution. At the same time, excellent individuals also have a high probability of being retained.

4. Conclusions

This paper proposes a BP neural network controller based on improved genetic algorithm. The controller not only makes full use of the local time domain characteristics of BP network and the global optimization search ability of genetic algorithm, but also enhances the intelligent search capability of the network and overcomes it. Some of the shortcomings of the basic genetic algorithm. The improved genetic algorithm is used to optimize the weight and threshold of BP neural network, which improves the training speed and handwritten digit recognition rate of BP neural network. The BP neural network is prevented from falling into local extreme points, which causes a large network prediction error. At the same time, the scheme has the advantages of both extensive mapping ability of neural network and fast global convergence of genetic algorithm. To solve the problem of slow evolution of random initial population in the scheme, information gain is used to measure the influence of features on categories, and the features with higher influence are given higher initialization probability. It improves the evolution speed of genetic algorithm. From the actual simulation results, it can be seen that the neural network input layer neuron selection method designed in this paper is effective. Of course, the neural network technology based on the improved genetic algorithm needs to continue to study, improve and develop.

References

[1] Yu F, Xu X. A short-term load forecasting model of natural gas based on optimized genetic algorithm and improved BP neural network[J]. Applied Energy, 2014, 134:102-113.

[2] Zhang Y, Gao X, Katayama S. Weld appearance prediction with BP neural network improved by genetic algorithm during disk laser welding[J]. Journal of Manufacturing Systems, 2015, 34:53-59.

[3] Li D J, Li Y Y, Li J X, et al. Gesture Recognition Based on BP Neural Network Improved by Chaotic Genetic Algorithm[J]. International Journal of Automation and Computing, 2018, v.15(03):21-30.

[4] Luo F L. An Improved BP Neural Network Algorithm and its Application in Competitive Advantage Evaluation of Logistics Enterprises[J]. Advanced Materials Research, 2014, 850-851:788-791.

[5] Ke G, Hong Y H. The Research of Network Intrusion Detection Technology Based on Genetic Algorithm and BP Neural Network[J]. Applied Mechanics and Materials, 2014, 599-601:726-730.

[6] Bi Z M, Wang Y. Method of flatness pattern recognition based on improved genetic algorithm optimization Elman neural network[J]. Journal of Iron and Steel Research, 2017, 29(4):305-311.

[7] Soltanali S, Halladj R, Tayyebi S, et al. Neural network and genetic algorithm for modeling and optimization of effective parameters on synthesized ZSM-5 particle size[J]. Materials Letters, 2014, 136:138-140.

[8] Xue Y, Cheng L, Mou J, et al. A new fracture prediction method by combining genetic algorithm with neural network in low-permeability reservoirs[J]. Journal of Petroleum Science and Engineering, 2014, 121:159-166.