

# Research on Optimization Model of Neural Network Based on Genetic Algorithm

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**Abstract.** BP neural network is a multilayer feed-forward network for training according to the error back-propagation algorithm, its main advantage is the strong non-linear mapping ability, but the training of BP neural network is easy to fall into local minima, and slow convergence speed. This paper makes use of the good global search ability of genetic algorithm, for training the connection weights and thresholds of BP neural network, establishment of GA-BP model, effectively compensate slow convergence speed, easy fall into local minimum shortcomings for BP neural network. Through example analysis, verification of the global optimization capability of GA optimization BP neural network has been greatly improved compared with the pure BP neural network model.

## Introduction

Artificial neural network from the origin to the present, no substantive progress on the connection weights of the problems in the research on the process. Then BP neural network is put forward, and provides a method to solve this problem. In the present stage in the field of artificial neural network, the application of BP neural network is still the most extensive. But it also has some shortcomings, the training time is long, easy to fall into local minimum.

Genetic algorithm with global searching ability, can effectively avoid the problem of BP neural network into a local optimal. Using the method of genetic algorithm and BP neural network combination, try to analyze the genetic algorithm to optimize the network structure and parameters. By modifying the initial values and parameters know which genetic algorithm to a certain degree of improvement stability and high efficiency of the neural network, can be optimized for the original algorithm.

## Neural network

Neural network is an active frontier interdisciplinary subject. It is not only the basis of large-scale parallel computing and parallel processing, and is a highly nonlinear dynamic system and the adaptive organization system, can be used to describe cognition, decision and control of intelligent behavior. Its central question is the cognitive and intelligent simulation. In the ANN model, a multilayer feed-forward neural network model is the most widely used model. BP(Back Propagation) neural network is one of the most common multilayer feed-forward neural network model, this paper uses genetic algorithm to study the optimization of neural network.

BP (Back Propagation) network is a group of scientists led by Rumelhart and McClelland put forward in 1986, is a kind of error back-propagation algorithm for training multilayer feed-forward network, its learning rule is to use the method of steepest descent, to constantly adjust the network weight value and threshold value by back propagation, make the network and the minimum sum of square error. BP neural network is mainly composed of an input layer, one or more hidden layers and one output layer, the mutual connection between the layers of neurons, but between each layer

between the neurons are not connected relationship.

The learning process of the BP neural network model composed of by two parts, forward and backward. In the forward process of communication, information from the input layer through the middle hidden layer to the output layer weighted propagation, in the output layer to obtain the input of the network response, output value by comparing the function calculation and target output value, if there are errors, error back propagation along the route before the return, i.e., from the output layer after each intermediate the hidden layer to adjust the connection weights, finally back to the output layer, to reduce the error, with the neural network error reverse spread to revise the weights continuously, the entire network accuracy of input information in response to natural also improved.

### Genetic algorithm (GA) optimize BP neural network

Neural network is a computational model to simulate the neural mechanism of human physiology, which in the feed forward network is the most used BP algorithm. The BP algorithm is based on the gradient descent of this nature, therefore inevitably brings about the following three shortcomings:

- (1) the learning process of slow convergence speed;
- (2) Algorithm of incomplete, is easy to fall into local minima ;
- (3) The robustness is not good, the network performance is poor.

Aiming at this problem, put forward first by using genetic algorithm (GA) to optimize the weights and thresholds of the BP neural network, the local search advantage of the global searching ability of the particle swarm algorithm and BP algorithm, can be used to overcome the weights of BP neural network to random question, not only can improve the BP neural network the generalization ability, but also can improve the learning ability of neural network.

In the BP neural network, the weights initialization strongly affect the final solution. The initial weights of different settings may cause great differences on the training time and convergence. In order to better solve the problems of determine the initial weights and threshold, can adopt the weights and threshold based on genetic algorithm, using the global search ability of genetic algorithm to determine the initial weights and threshold. This paper adopts three layer BP network to determine the initial solution space, setting training number and training error of the network. when the training sample error and testing samples are more satisfied , respectively recorded maximum value and minimum value of the connection weights as  $w_{\max}$  and  $w_{\min}$ . Set the solution space of the connection weights as  $[w_{\min} - \delta_1, w_{\max} + \delta_2]$  ( $\delta_1, \delta_2$  is adjusting parameters). The chromosome representation the weights, then the fitness function is the calculation error of the neural network, and the error is larger, the fitness is smaller. The GA fitness function can be use of

$$fitness = \frac{1}{\frac{1}{N} \sum [y_k(t) - \hat{y}_k(t)]^2} \quad (1)$$

$y_k(t)$  and  $\hat{y}_k(t)$  are the expected value and the actual value of the network output. N is constant.

Set the input population size, crossover probability ( $P_c$ ), mutation probability ( $P_m$ ), the network layers, each layer neural meta-data, and use GA to optimize the weights of neural network repeatedly, until the average value is no longer meaningful increase so far, at this time the decoded parameter combination has sufficiently close to the optimum combination of parameters, and then BP algorithm re-optimization connection weights and threshold of the network in the small solution space , search out the optimal solution[4].

Because GA is based on the population, not to search base on a single point , can also obtain a plurality of extreme value from different points, so it is not easy to fall into local optimum, which can effectively solve the existing problem in BP neural network, and effectively improve the generalization performance of neural network.

## Empirical Analyses

The calculation example is to calculate the typical function optimization to validate the feasibility and effectiveness of the algorithm.

(1) Genetic algorithm is used to select the global optimal solution

For typical constrained optimization problem:

$$f(x) = 5.885x_4(x_1 + x_3) / (x_1 + (x_3^2 - x_2^2)^{1/2}) \quad (2)$$

have four design variables :  $[x_1, x_2, x_3, x_4]^T$ , the constraint functions are as follows:

$$x_2x_4(0.4x_1 + x_3 / 6) - 8.94(x_1 + (x_3^2 - x_2^2)^{1/2}) \geq 0 \quad (3)$$

$$x_4 - 0.0156x_1 - 0.15 \geq 0 \quad (4)$$

$$x_4 - 0.0156x_3 - 0.15 \geq 0 \quad (5)$$

$$x_4 \geq 1.05 \quad (6)$$

$$x_3 \geq x_2 \quad (7)$$

Take the population size and modulus of 30, the hybridization rate was 0.8, obtained the results as shown in table 1:

Table 1 Using GA select the global best solution

iterations	X1	X2	X3	X4	objective function value
0	46.3343	47.2629	79.2766	1.7644	11.859
30	48.1915	29.5210	59.1886	1.1045	7.0158

(2) Design of neural network

Table 2 Using BP network learn the results of table 1

iterations	X1	X2	X3	X4	objective function value
0	48.1915	29.5210	59.1886	1.1045	7.0158
27	42.0860	30.0917	58.5083	1.0945	7.0023

From the experiment we can draw the following conclusions: by using a combined method of artificial neural network and genetic algorithms to solve complex optimization problems, can be overcome simply generated by genetic algorithm and BP neural network, individual premature phenomenon and easily local convergence, make full use of the merits of the two algorithms together to better solve the optimization problem becomes more and more complex.

## Conclusion

This paper improved some shortcomings aiming at BP neural network, genetic algorithm is used to optimize the BP neural network. GA can optimize BP neural network from the aspects of the learning efficiency and global optimization. The last example analyzed through the MATLAB simulation platform, from the table 2 we can found that the optimized model calculation result is perfect, if the algorithm is extended to practical applications, will achieve good results.

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