# **Review of swarm intelligence algorithm optimization of BP neural network**

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**Abstract:** As a model used for parameter estimation, BP neural network has a remarkable effect in many prediction algorithms. However, there are situations that will fall into the local optimal solution and the learning speed is slow. To solve these two problems, this paper combines the dynamic adaptive strategy in the genetic algorithm, the method of eliminating honey sources in the bee colony algorithm, the adaptive greedy strategy in the ant colony algorithm, and the introduction of variation operator in the particle swarm algorithm to improve the two defects of the BP neural network, It has made optimization research on the use of BP neural network and prediction, and also laid the groundwork for the future research on optimization of BP neural network.

*Keywords:* BP neural network, genetic algorithm, bee colony algorithm, ant colony algorithm, particle swarm algorithm

## 1. Introduction

## 1.1 Background

BP neural network is a model of parameter estimation. The diversity of algorithms in the field of parameter estimation is self-evident. Among various algorithms, BP neural network model has relatively significant effect.

BP neural network is mainly used in function approximation, pattern recognition, classification, data compression and other fields, which shows that BP neural network is often used in some data estimation algorithms, for example, it has an indelible contribution to identifying network intrusion.

However, BP neural network will have the problem of slow convergence in data estimation, and it generally needs hundreds of iterations to improve in a learning process. In addition, it is easy to fall into the local optimal solution. In this paper, the problems existing in BP neural network are reasonably improved and summarized through genetic algorithm, bee colony algorithm, ant colony algorithm, particle swarm optimization algorithm and other swarm intelligence optimization algorithms, which has certain reference value for the subsequent research of BP neural network.

## 1.2 Overview

When the input signal is transmitted forward, the sample data xi is input from the input layer, processed by the neural unit in the hidden layer, and transferred to the output layer to obtain the output result y of the output layer. If there is an error with the expected value of y and the error is large, the hidden layer can be back-propagated for calculation again<sup>[1]</sup>. The specific algorithm is shown in Figure 1 below.



Figure 1: Neural network topology

## 1.3 Research status and purpose

BP neural network has the advantages of simple structure and nonlinear mapping. BP neural network reaches the output layer through the hidden layerIt has been applied to data estimation, such as quantitative prediction of wire icing, identification of network intrusion, etc., which is of great significance in the digital era;At the same time, a series of derivative functions are derived from the estimation of data, such as identifying network intrusion through the prediction of passenger flow.If it can effectively jump out of the local optimal solution, it will be of great help to many fields requiring rapid valuation.

## 2. Optimization algorithm and how to optimize

## 2.1 Genetic algorithm

## 2.1.1 Introduction to Genetic Algorithms

Genetic algorithm is an algorithm for solving the optimal solution and approximate optimal solution.Genetic algorithm simulates the phenomenon of selective reproduction, gene crossover and gene mutation in the principle of genetic theory in nature. In each iteration, a group of optimal candidate solutions are reserved to avoid elimination, and then appropriate individuals are selected from the solution group according to the value of fitness function. Finally, genetic operators are used to recombine these individual genes to form a new population, In this way, the new generation population contains a lot of information about the previous generation, but it is better than the previous generation population. In this way, the iteration can be stopped until the goal requirements are met<sup>[1]</sup>.

## 2.1.2 Application of genetic algorithm

BP neural network has the disadvantage of slow convergence, which can be weakened by the phenomenon of premature convergence of genetic algorithm.

The advantages of the model of genetic algorithm lie in ① fast and random search ability; ②The search starts from the group, has potential parallelism, and can compare multiple individuals at the same time; ③Search is inspired by evaluation function, and the process is simple. The disadvantages of using genetic algorithm are as follows: ① The programming implementation of genetic algorithm is relatively complex. First, you need to code the problem, and then you need to decode the problem after finding the optimal solution; ②The implementation of the other three operators also has many parameters, such as crossover rate and mutation rate, and the selection of these parameters seriously affects the quality of the solution. At present, the selection of these parameters mostly depends on experience<sup>[2]</sup>.

BP neural network also has the disadvantage of falling into the local minimum. In view of its lack of global convergence, a dynamic adaptive strategy is proposed to improve its performance. On the basis of the basic genetic operator, immune genetic operator and optimal strategy<sup>[3]</sup> are adopted.

The immune operator can prevent individual degeneration in cross mutation, and the adaptive strategy maintains the diversity of the population to ensure that the genetic algorithm converges to the global optimal solution as soon as possible, which is called adaptive immune genetic algorithm (AIGA)<sup>[3]</sup>. The adaptive strategy can make pc and pm change automatically with the fitness. When the individual fitness in the population tends to be uniform or locally optimal, it makes pc and pm increase, while when the fitness is relatively dispersed, it makes pc and pm decrease. At the same time, individuals whose fitness is higher than the average fitness of the population will be given lower pc and pm to protect them into the next generation,; The individuals below the average fitness value will be given higher pc, pm, so that they will be eliminated. In addition, we can also use the global search function of genetic algorithm to reduce the disadvantage of falling into local minimum.<sup>[3]</sup>

#### 2.2 Bee colony algorithm

#### 2.2.1 Brief introduction of artificial bee colony algorithm

The three roles of artificial bee colony algorithm are honey source, hired bee and non-hired bee. Honey source is a feasible solution to the optimization problem. Hired bees are also called leading bees. Here, there are as many leading bees as there are honey sources. Non hired bees are reconnaissance bees and following bees. The reconnaissance bees are responsible for actively finding honey sources, and the following bees are responsible for following the leading bees to find small honey sources beside the honey sources. One following bee corresponds to one leading bee.

When solving optimization problems, we often use the artificial bee colony algorithm to calculate, and there are some interesting mechanisms. For example, when following bees to find small honey sources, if they find that small honey sources are more dominant, they will replace small honey sources for large honey sources.(Judge adaptability).In the calculation of the probability of following the leading bee, we introduce the roulette wheel gambling algorithm based on fitness.

The algorithm generated by the reconnaissance bee can be used to jump out of the local optimal solution and find the population optimal solution.

#### 2.2.2 Application of artificial bee colony algorithm

In the case of slow convergence of BP neural network, there are the following solutions: reasonably use multi-dimensional search greedy selection and gradient descent algorithm to accelerate effective convergence speed, and we choose multi-dimensional optimization strategy to overcome blindness in the case of prior information of unknown functions, which can also greatly improve the speed of honey source search.<sup>[4]</sup>

For the problem that the BP neural network has fallen into the local optimal solution, we can use the multidimensional search optimization strategy. Wang Xiu mentioned the method of eliminating honey sources to prevent the data from reaching the local optimal solution. The specific algorithm is: when a honey source exceeds the limit number of times and is not updated, we determine that the honey source has reached the local optimal solution and eliminate it. Its corresponding leader bee becomes a reconnaissance bee.<sup>[5]</sup>Using the historical experience value of the reconnaissance bee, the reconnaissance peak no longer appears only when food is scarce, but appears and reconnoiters globally.

#### 2.3 Ant colony algorithm

#### 2.3.1 Introduction to Ant Colony Algorithm

Ant colony algorithm is an algorithm that leaves pheromones and other symbols on the way to solve problems through various attempts to obtain the shortest path.

Usually, the ant colony algorithm emphasizes strengthening local optimization and randomness. Randomness means that we want to jump out of the local optimal solution, in which we can strengthen a better solution through iteration. The local optimization of reinforcement can be divided into two situations: too few pheromones will lead to too little reinforcement, and too many pheromones will lead to the situation that the randomness cannot be guaranteed due to excessive reinforcement. Here, randomness is usually expressed as the speed of volatilization. We hope to speed up the volatilization to

enhance randomness so as to jump out of the local optimal solution.

## 2.3.2 Application of ant colony algorithm

Using the ant colony algorithm, researchers hope to optimize the initial weight value by optimizing the search range of the BP neural network through the global search ability of the ant colony algorithm, which can effectively speed up the algorithm of the BP neural network and reduce the probability of entering the local optimal solution. This algorithm also uses adaptive greedy strategy to prevent entering the local minimum.<sup>[6]</sup>

## 2.4 Particle Swarm Optimization

#### 2.4.1 Introduction to Particle Swarm Optimization

The flow chart of particle swarm optimization algorithm is shown in Figure 2.



Figure 2: Flow chart of particle swarm optimization algorithm

The advantage of the algorithm is that it is simple in principle and easy to realize with few parameters, while the disadvantage is that it is easy to prematurity and converge to local optimum, or even slow in the late iteration. The BP neural network has the disadvantage of slow convergence, and the combination of these two algorithms will have a positive effect.

In the algorithm, the  $\Omega$  parameter represents the inertia index of particles, which should be larger in the early stage to facilitate our exploration of the overall situation, and smaller in the later stage. At this time, the global optimal solution has been locked, and efforts should be made to move closer to the global optimal solution. The same is true for C1, which describes the individual learning coefficient of particles.C2 describes the social coefficient, and the parameter should be set to small in the front and large in the rear to facilitate the precocity after finding the local optimal solution in the later stage to prevent the iteration rate from being too slow.<sup>[7]</sup>

## 2.4.2 Application of Particle Swarm Optimization

By establishing multiple clusters with the ability of information exchange and introducing the "mutation operator"<sup>[8]</sup>in the evolution process of particles, in addition, the nonlinear decline of particle swarm can also enhance its optimization<sup>[9]</sup>. Compared with the traditional model, it greatly reduces the probability of falling into the local extreme value, and guides particles to the global optimal solution in the search process.It can be applied to the prediction of sea level and grain temperature in the warehouse<sup>[10]</sup>.

### 3. Algorithm summary

The comparative analysis of swarm intelligence algorithms is shown in Table 1.

Author and literature	algorithm	Application value	Direction of optimization	Application
			problem	scenarios
Xiong Zhibin	genetic algorithm	Easier to achieve fast convergence	Combination of adaptive immune genetic algorithm and BP neural network	Credit evaluation
Wang Xiu	Bee colony algorithm	Prevent local optimal solution	Combination of multi- dimensional search optimization and BP neural network	Combination with other algorithms such as clustering
Xia Le	Ant colony algorithm	Increase global search capability	Combination of adaptive greedy strategy and BP neural network	Temperature balance of heating system, etc
Zhang Yu, He Xiaoxing, Sun Xiwen	Particle Swarm Optimization	Guide to global optimal solution	Intelligently adjust the search strategy to achieve global optimization	Prediction and analysis of sea level change

Table 1: Comparative analysis of swarm intelligence algorithms

## 4. Summary

In this paper, genetic algorithm, bee colony algorithm, ant colony algorithm and particle swarm algorithm are used to optimize the BP neural network, which has two disadvantages of slow convergence and easy to fall into local optimal solution. There are applications of BP neural network in various fields. However, due to the particularity of some special situations, there are still shortcomings, such as the difficulty of sample selection. In the future research, we can continue to improve the BP neural network by combining the fast selection algorithm of relevant samples.

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