# Analysis of the application value of neural network in the evaluation of computer network security

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## ABSTRACT

With the rapid development of science and technology, more and more people use the network to communicate with each other, but the consequent network security problem has attracted a wide attention. The factors that affect the computer network security, such as computer viruses, Trojan horses and loopholes, can reduce the safety factor of computer network. So, it is very crucial to construct the evaluation criteria and evaluation methods for the computer network security evaluation model. It will affect the computer network security directly. All the evaluation methods that the existing computer network security evaluation models use can result in the higher errors. But, according to the characteristics of existing computer network security evaluation models, this study embeds the neural network technology in the computer network security evaluation system, and combines the BP neural network technology optimized by the PSO algorithm and computer network security evaluation system to get an optimization-based neural network computer security evaluation system. Finally, the simulation results show that compared to the existing computer network security evaluation models, the computer network security evaluation model of BP neural network technology based on PSO algorithm both increases the evaluation efficiency of network security and improves the evaluation accuracy of network security.

## KEYWORDS

Neural network; Network security; Evaluation methods; PSO algorithm.

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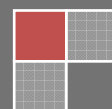
# INTRODUCTION

With the wide application of computer and the popularization of Internet, the communication in the network is becoming more and more frequent and the network security problems are becoming more and more serious. Specifically, the computer viruses, Trojan, loopholes and other factors are the main factors that cause the computer network security problems[1]. And also there is more complex nonlinear relationship among the multiple factors. The evaluation accuracy of original computer network security evaluation system is low relatively, such as the fault tree analysis method, analytic hierarchy process and grey model and so on. The so-called expert network security evaluation system is another different evaluation method, and it requires that the experts have rich evaluation experience in the evaluation process. Also, the evaluation results are subjective and the safety evaluation lack of scientific rigor which is not suited to the system in which the evaluation factors relationship is complex and diverse[2]. The neural network technology has become a hot research subject for years. The technology has a strong self-improvement and adaption ability; the application of its algorithm is simple and it has a good anti-jamming capability. The artificial intelligence model based on neural network technology can be combined with computer network security evaluation model, and can realize the scientific and rigorous evaluation for computer network security. So the model is well suited for the computer network security evaluation of this stage.

# RELATED THEORY OF THIS STUDY

## The development and characteristics of neural network

The early 1940s, the world's first neural network model was put forward by the cooperation of mathematicians and neurobiologists. It regards the approach of the human brain processing information as the basis, through constructing a mathematical model to study the structure and behavior of the brain cells and the basic physiological characteristics of the biological neurons, thereby creating the study of neural network[3].

Neural network is a kind of artificial intelligent information processing system to imitate the structure and function of human brain. It is a complex network structure which is connected and formed by a large number of neurons in a particular manner, in which each neuron can store and deal with the required information and can do interact work with other neurons.

Neural network theory is the intelligent behavior which is based on the parallel processing and parallel computing of a lot of information. It is both non-linear dynamical systems and the adaptive system and can be used to describe the decision-making, cognition and control[4]. In addition, the self-learning process only requires a part of the neurons points to join in the work, and when certain nerve points fails, other neurons points with the similar function can also be take advantage of to instead of them to participate in learning, thereby allowing the system without interruption. it has a strong fault tolerance.

Specifically, the neural network model forms the network by the connection of a series of processing units. It is the abstraction, simplification and simulation of human brain, and therefore the basic features of the human brain can be observed from the model. The neural network models are classified from the perspective of topology and learning methods and more than 60 different neural network models has been discovered, including adaptive resonance model, Hopfield neural network model, BP neural network model and fuzzy neural network[5]. These neural network models were applied to different research areas respectively.

## Computer network security and evaluation system

### Computer network security

Computer network security is to use of advanced science and technology and network control technology to protect the integrity, usability and confidentiality of the computer data in a networked environment. Concretely, computer network security can be divided into logical security and physical security. Logical security mainly includes the protection to the integrity, usability and confidentiality of the information data in the computer; physical security mainly refers to the protection to the computer-related hardware and system equipment[6]. Computer network security includes the management control system network software, networking hardware facilities, convenient network services, shared resources and other aspects. Due to the computer network have the characteristics of openness, controllability and freedom, so it may suffer from the attacks of physical transmission line, loopholes of computer software and hardware and network communication protocol.

### Introduction to computer network security evaluation system

Computer network security evaluation system is established for the influence factors of computer network safety. The system can reflect the main factors which influence the computer network security comprehensively, objectively and scientifically[7]. The first level evaluation index of computer network security evaluation system consists of physical security, logical security and management security. The evaluation indexes of physical security include electricity supply security, network computer room security, equipment safety, redundant fault-tolerance, line safety and anti-electromagnetic leakage measures. The evaluation indexes of logical security include anti-virus measures, software security, intrusion prevention, data encryption, system audit, digital signature, access control, data backup and data recovery. The establishment principle of computer network security evaluation system includes feasibility, independence, completeness, accuracy and conciseness.

## THE ESTABLISHMENT OF COMPUTER NETWORK SECURITY EVALUATION SYSTEM

**The evaluation methods of computer network security**

     This study adopts the BP neural network technology in neural network. BP neural network technology is a mature technology which is widely used nowadays, but its design is made according to the gradient descent algorithm and it has the shortcomings that the train efficiency is slower and the global search capability is weak. So, if it is embedded into the computer network security evaluation model directly, the evaluation results can not be guaranteed[8]. The study analyzes the particle swarm algorithm in details and the algorithm is the emerging search algorithm which simulates the birds flying trajectory. Also, this algorithm needs less sample data and has strong global search ability, such as using the particle swarm algorithm to optimize neural network can effectively make up for the disadvantages of neural network. This study starts from the current computer network security evaluation criteria and builds a computer network security evaluation model of BP neural network technology based on PSO algorithm. The simulation experimental results show that[9], this improved computer network security evaluation model has a better evaluation effect.

**The evaluation mechanism of computer network security**

     According to the specific indexes for the evaluation of computer network security, the computer network evaluation mechanism of this study determines the object's evaluation scope at first, also, it should refer to the specific situation of the computer network and make the evaluation by using the scientific evaluation methods to get the safety index of the network, the mathematical formula is:

$$\text{Network safety index} = f(x_1, x_2, \dots x_m) \tag{1}$$

     In formula (1), $x_i$ refers to the evaluation factor of network security and function $f(x_1, x_2, \dots x_m)$ refers to the evaluation function of network security.

     Obviously, choosing different evaluation factors of network security and different evaluation functions of network security will produce different evaluation results. So, According to the randomness and non-linear characteristics of the computer network, it is a perfect way to improve the reliability of computer network security evaluation by embedding BP neural network into a computer network security evaluation model and using the rich experience of experts to evaluate their network security evaluation factors to get the required weights for evaluation.

**The evaluation system of computer network security**

**The evaluation index of computer network security**

     Strictly speaking, computer network is a cumbersome and complex network. It should take into account almost all factors that affect network security, so as to build a rigorous and scientific evaluation index of computer network security[10]. This study fully considers the requirements of computer network system in the aspects of management security, logical security and physical security and through the experts' system to evaluate its network security evaluation index to determine their weight. The specific data is shown in Figure 1:
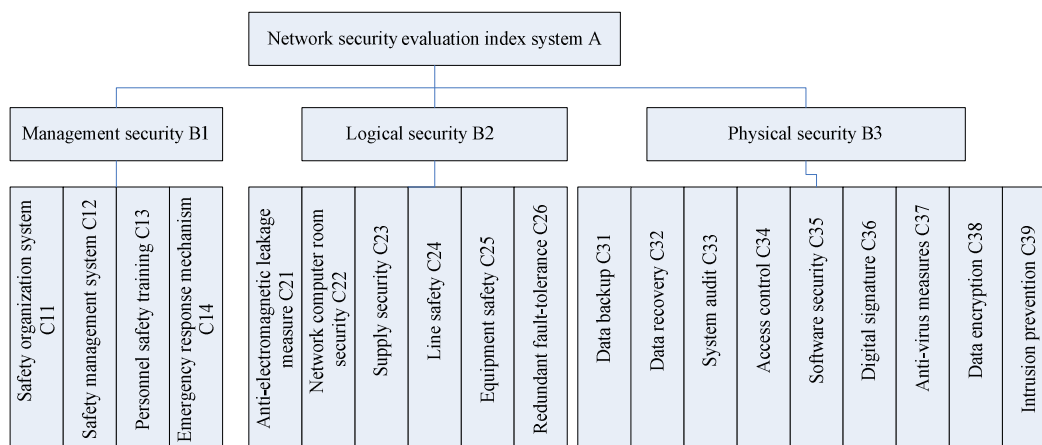


**Figure 1 : Computer network security evaluation index system**

**Computer network security index processing**

     As shown in Figure 1, the computer network security indexes reflect the computer security situation from different aspects, but because each security index which represents the different dimension, they can not be directly compared. Now, in order to make every safety index can be compared and calculated, it is necessary to make a uniform dimension processing

for all safety indexes: 1. The qualitative of safety indexes: through the experts' rich experience to evaluate its network security evaluation index to determine their weight, and then make a uniform dimension processing for all indexes; 2. The quantitative of safety indexes: may use the following mathematical formula for uniform dimension processing, the safety index weight is:

$$x_i = (x_i - x_{\min}) / (x_{\max} - x_{\min}) \tag{2}$$

In it, $x_i$ is the unified standard weights of security index $x_i$. $x_{\max}$ and $x_{\min}$ refer to the maximum weight and minimum weight of the No.i security index respectively.

Here, the evaluation of computer network security will be carried out according to the weight of safety index. Specifically, computer security evaluation levels can be divided into four, namely: security (grade A), basic safety (grade B), insecurity (grade C) and extreme insecurity (level D), The corresponding value of each security level is shown in the following TABLE 1:

**TABLE 1 : Computer network security levels**

| Level | A | B | C | D |
|---|---|---|---|---|
| Value | 1~0.85 | 0.85~0.7 | 0.7~0.6 | 0.6~0 |

**The related algorithm of computer network security evaluation**

Specifically speaking, BP neural network is a technology based on reverse error. Now, it has become a mature neural network technology. Its neural network designs the algorithm based on gradient descent and adjusts the weights and thresholds of network to make the total error between the expected value of output and the actual value of output become the minimum. The structure figure of BP neural network is shown in Figure 2:
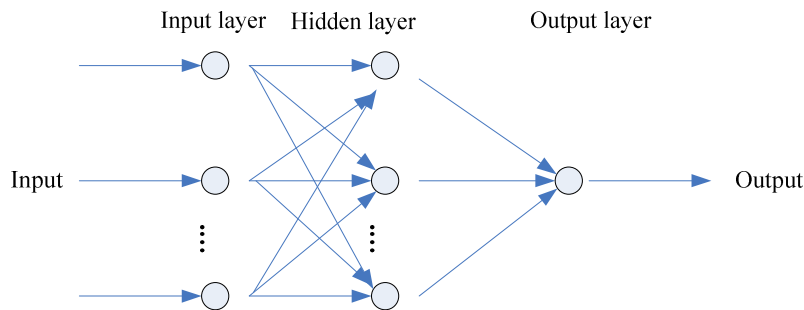


**Figure 2 : The structure figure of BP neural network**

In order to make up for these shortcomings of BP neural network, this study uses the PSO algorithm in BP neural network to improve it. The steps are as follows:

**(1)** First, initialize the target vector and transfer function of BP neural network.
**(2)** According to the actual needs, set the upper limit of iterations of the particle swarm and the largest scale, as well as set the initial velocity and position of particles randomly.
**(3)** Using the training set to train the BP neural network and evaluate the adaptation situation of particles.
**(4)** Make a comparison between the original global optimal value and the current value of particles and take the optimal value of both.
**(5)** Calculate the inertia weight of BP neural network.
**(6)** To update the velocity and position of the particle timely, and save the difference of the adaptive value between individual particles and particle swarm.
**(7)** According to the error limit and the upper limit of iterations, if the error of the system adaptive value exceeds one of them, the training is over; at this time, the original global optimal value of particles is the optimal weights and thresholds which are needed by the BP neural network.

**Study on simulated experiment**

The study designs the computer network security model of BP neural network which is based on PSO algorithm. the design idea is: to design the model based on the evaluation index of computer network security mentioned above, and combine with the BP neural network technology by PSO algorithm to obtain the optimal weights and thresholds of BP neural network through the above improvement methods, then to obtain the computer network security model of BP neural network based on PSO algorithm. The specific design process is shown in Figure 3:
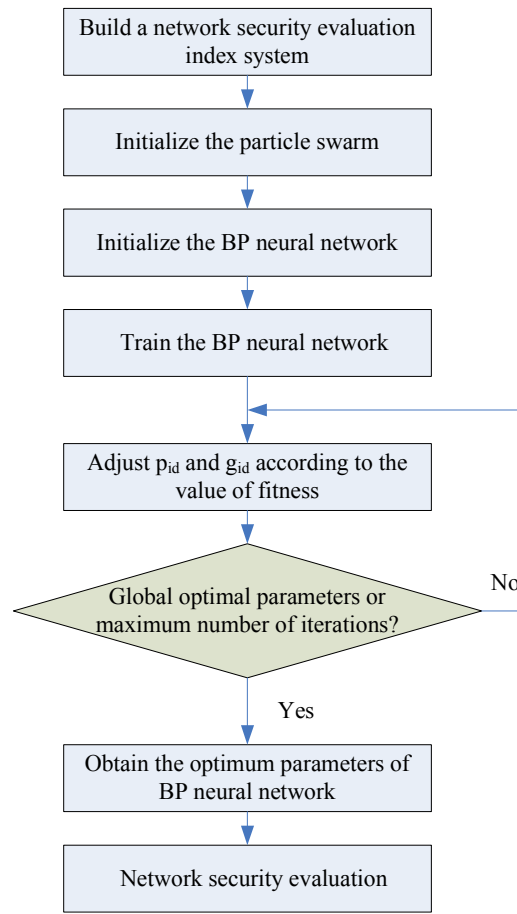
**Figure 3 : The evaluation processing of computer network security**

There are 50 groups' experimental data for this study. They are the evaluation data of network security with different specifications. The unified dimensional processing is made for all the experimental data. The computer network security evaluation of BP neural network based on PSO algorithm trains the first 45 groups experimental data while the test data uses the another 5 groups experimental data. The specific experimental simulation data is shown in TABLE 2:

**TABLE 2 : The simulation data set of computer network security**

| Number | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{21}$ | $C_{22}$ | $C_{23}$ | $C_{24}$ | $C_{25}$ | $C_{26}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.8 | 0.8 | 0.8 | 1 | 0.8 | 0.85 | 0.8 | 0.72 | 0.8 |
| 2 | 1 | 1 | 0.8 | 0.8 | 1 | 0.9 | 0.85 | 0.8 | 0.77 | 0.8 |
| … | … | … | … | … | … | … | … | … | … | … |
| 49 | 0.2 | 0.4 | 0.2 | 0.2 | 0 | 0.3 | 0.3 | 0.2 | 0.27 | 0.2 |
| 50 | 0.8 | 0.8 | 0.4 | 0.6 | 1 | 0.5 | 0.6 | 0.6 | 0.64 | 0.6 |
| Number | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{34}$ | $C_{35}$ | $C_{36}$ | $C_{37}$ | $C_{38}$ | $C_{39}$ | Expected output |
| 1 | 0.92 | 0.87 | 0.85 | 0.8 | 0.93 | 1 | 0.8 | 0.8 | 0.9 | 0.85 |
| 2 | 0.93 | 0.9 | 0.9 | 1 | 0.95 | 1 | 0.8 | 0.6 | 0.9 | 0.88 |
| … | … | | | | | | | | | … |
| 49 | 0.33 | 0.37 | 0.25 | 0.2 | 0.35 | 0 | 0.2 | 0.2 | 0.4 | 0.24 |
| 50 | 0.75 | 0.77 | 0.8 | 0.6 | 0.78 | 0 | 0.6 | 0.4 | 0.7 | 0.63 |

The experiment sets up the learning factor as $m_1 = m_2 = 2$, the scale of particle swarm as $n = 10$. It chooses the optimal value from all particles as the optimal weights and thresholds of BP neural network based on PSO and stipulate the upper limit of iterations is $N = 500$, and set the position of the particles randomly. It regards the original BP neural network model as the comparison model of the experiment, and sets the error amount to 0.001 while the excitation function is traingdx.

The study uses the first 45 groups' experimental data as the training data of the two models. The experimental data show that the convergence efficiency of the existing BP neural network is slow, and it is over after 417 iterations, and the error amount is 0.000884; relatively speaking, convergence efficiency BP neural network based on PSO is higher, and it is over after 312 iterations, and the error amount is 0.000751. Through comparison, it is not difficult to see that the application of PSO algorithm plays an optimization function for BP neural network. It not only improves the convergence speed, but also improves the accuracy.

**Analysis of simulation results**

As shown in TABLE 3, the study compares the experimental data of two kinds of models. From TABLE 3, it is not difficult to see that the original BP neural network has wrong evaluation results for the 47th data, and the evaluation results should be grade C, the insecurity level, but the original BP neural network evaluation is extreme insecurity level. However, the correct rate of the evaluation is 100% by using PSO-BPNN model. Comparing from the other side, the root mean square error of the traditional BP neural network is much larger than the RMSE of PSO-BPNN model, which illustrates that the optimization of BP neural network model based on POS is effective. It not only speeds up the convergence rate, but also improves the experimental accuracy greatly.

**TABLE 3 : Comparison of evaluation results**

| Sample | Security level | Expected output | BPNN | PSO-BPNN model |
|--------|----------------|-----------------|------|----------------|
| 46 | D | 0.46 | 0.41 | 0.44 |
| 47 | C | 0.61 | 0.55 | 0.64 |
| 48 | A | 0.85 | 0.76 | 0.86 |
| 49 | D | 0.24 | 0.19 | 0.26 |
| 50 | C | 0.63 | 0.69 | 0.66 |
| Root mean square error | | | 0.067 | 0,023 |

**CONCLUSIONS**

This study researches the inherent characteristics of the BP neural network and refers to the shortcomings of the original BP neural network, such as the convergence efficiency is low and the global search capability is poor. It uses the PSO algorithm to optimize the model to obtain the optimal weights and thresholds of BP neural network, thus improving the evaluation effect of computer network security evaluation model effectively. The experimental simulation data shows that: the efficiency convergence of computer network security model of BP neural network based on PSO is higher and the evaluation accuracy has also been significantly improved. It illustrates that the safety evaluation results of computer network security evaluation system of BP neural network which is based on PSO algorithm is very effective.

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