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Research Article

Optimization of TCM Diagnosis Information Management System Based on Artificial Neural Networks

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As a treasure of Chinese medicine, TCM has gradually formed and developed into a complete medicine with a unique medical theory system and rich treatment experience after thousands of years of medical practice. It requires high diagnostic experience, which is not conducive to application promotion and management. Therefore, the concept of digital medicine has been recognized by more and more people, in which medical diagnosis is one of the core issues of digital medicine. The accuracy and efficiency of medical diagnosis are closely related to people's life and health, which is an important problem that cannot be ignored. Use the growing case base as knowledge base to reason and realize the diagnosis function of traditional Chinese medicine. Based on the characteristics of traditional Chinese medicine and taking case reasoning as a model, an expert system of traditional Chinese medicine diagnosis is established. This paper combines the strong learning ability, strong adaptability, and large-scale parallel processing ability of artificial neural networks (ANN) to solve the nonlinear and unstructured complex problems in management information system. By improving BP algorithm to optimize the error of weight and repair or energy parameters, the overall error of the optimized system is reduced by about 75.3% after experimental analysis, and the average accuracy of prediction is 75%.

1. Introduction

In the field of traditional Chinese medicine, the data is huge, the generation speed is fast, the structure is complex, and it has the characteristics of diversity, incompleteness, redundancy, privacy, ambiguity, and nonlinearity [1]. The structure of medical diagnosis system is very complex, there are many factors that need to be referred to, and the correlation between factors is very strong, so it is difficult to consider it comprehensively [2]. At present, in the process of medical treatment, the diagnosis of diseases by doctors is still in a traditional experience stage, which mainly depends on the practical experience of clinicians, various diagnostic indicators, and experimental examination results. A full-time doctor usually needs several years of practice to accumulate certain diagnostic experience [3]. Diagnostics is the use of medical knowledge to make a reasonable diagnosis of a disease based on clinical symptoms [4]. Unevenly distributed medical data is a difficult problem in the field of data mining, but neural network is one of the few analysis tools that can be used in this field [5]. Traditional Chinese medicine believes that there is interaction and causality between objects, and man is also an organic unity [6]. The local pathological changes of human body interact with the systemic pathological changes, and the systemic pathological changes can be reflected locally, and the local pathological changes may also produce systemic pathological reactions [7]. Clinical symptoms and TCM syndromes are the relationship between phenomenon and essence. Any syndrome has clinical symptoms, which reflects the basic law of syndrome development [8]. Different stages of TCM syndromes have different clinical symptoms, which reflect the nature of stages.

For the current general database management system, all it can do is carry out some simple query and report statistics, which cannot keep up with the needs of the times [9]. Faced with such a huge database, people want to process and analyze these data at a higher level to get the general characteristics of the data and the prediction of the development trend [10]. ANN is a simulation of human brain system, which reflects many basic features of human brain

function, but it is not a true portrayal of human brain nervous system, but a simplification and abstraction [11]. The purpose of our research on ANN is to study the basic mechanism of human brain storing and processing information and apply this principle to the actual engineering construction and the realization of related problems, so as to provide a practical method for solving a certain kind of problems [12]. It is generally believed that all biological nerve functions, including memory, are stored in neurons and their connections. Although the standard BP model has great advantages in all aspects, there are still many problems [13]. For example, the convergence speed of the learning algorithm is slow, it is easy to fall into the local minimum, and the network is only one-way propagation, which makes the learning results unsatisfactory [14]. It should be said that the key part of neural network modeling is the selection of its parameters. According to experiments and experience, the initial weight of BP model must be a small random number. Learning is seen as the process of establishing new connections between neurons or modifying existing connections [15]. Management information system is an information system with computer as a tool and system idea, which has the functions of data processing and decision-making and serves management.

Based on this, this paper mainly studies the application of ANN in the informatization of TCM diagnosis, in order to give full play to the recognition degree of ANN technology in TCM inspection and promote the development of TCM diagnosis in the direction of informatization. Hope to optimize the management information system in the improved BP neural network algorithm.

The process and characteristics of relevant neural network algorithm, evidence combination theory, and correlation algorithm are combed and briefly described, and an optimized neural network algorithm is established. The innovative contributions include the combination of natural language processing technology and data preprocessing methods to screen and process chaotic medical data. Chinese word segmentation of medical data, correlation research of medical symptoms, and quantitative processing of Chinese data are included. These are different from the traditional data processing. By training the symptom word vector, we can mine the semantic information of symptoms and diseases. In terms of node prediction accuracy, considering the application environment, the average accuracy is 75%, which can well meet the performance requirements of the application.

2. Methodology

2.1. Research and Analysis of ANN. Artificial neural network has four basic characteristics. (1) Nonlinear relationship is a universal characteristic of nature. Brain intelligence is a nonlinear phenomenon. Artificial neurons are in two different states of activation or inhibition. This behavior is mathematically nonlinear. The network composed of neurons with threshold has better performance and can improve fault tolerance and storage capacity. (2) Nonlocality a neural network is usually composed of multiple neurons widely connected. The overall behavior of a system depends not only on the characteristics of a single neuron, but also on the interaction and interconnection between units. Simulate the nonlimitation of the brain through a large number of connections between units. Associative memory is a typical example of nonlimitation. (3) Very qualitative artificial neural network has the ability of self-adaptation, self-organization, and self-learning. Not only can the information processed by neural network have various changes, but also the nonlinear dynamic system itself is constantly changing while processing information. Iterative process is often used to describe the evolution process of dynamic system. (4) Nonconvex evolution direction of a system will depend on a specific state function under certain conditions. For example, the extreme value of energy function corresponds to the relatively stable state of the system. Nonconvexity means that this function has multiple extreme values, so the system has multiple stable equilibrium states, which will lead to the diversity of system evolution.

ANN is a certain abstraction and simulation of biological neural network. Over the past decade, the research of ANN, more accurately, the application research of ANN, has reached unprecedented breadth and depth [16]. However, as its unique advantages, strong learning ability, strong adaptability, and large-scale parallel processing have not been clearly shown [17]. The prototype of the ANN is the biological neural network, which is constructed with reference to the structure and action or stimulation principles of the biological neural network. It uses information processing technology and network topology knowledge to simulate a kind of complex information processing and corresponding mathematical model [18]. The model has the ability of parallel distributed processing, high fault tolerance, and self-learning ability. It combines the acquired information through processing and storage and has attracted the attention of people in all walks of life with its unique knowledge expression and adaptive learning ability [19]. The basic unit of artificial network is neuron, and the neuron model structure includes input part, output part, and calculation function part [20]. After obtaining the weighted sum of the value of the input features and their corresponding weights, a scalar result is obtained through a nonlinear activation recursive function. The basic structure diagram of the neural network structure is shown in Figure 1.

The input layer receives the external signal and introduces it into the neural network. The hidden layer is located between the input layer and the output layer and is divided into one or more layers to process the input information and transfer the processed information to the output layer [21]. Forward propagation is the process that the input characteristic information enters the neural network from the input layer, passes through several intermediate layers, and finally outputs to the output layer. Backward propagation of errors is the process of propagating the error information from the output layer to the input layer in a reverse direction [22]. Nodes are usually represented as

$$\begin{aligned} a1 &= g\left(a1 * W_{1,1} + a2 * W_{1,2} + a3 * W_{1,3}\right), \\ a2 &= g\left(a1 * W_{2,1} + a2 * W_{2,2} + a3 * W_{2,3}\right). \end{aligned} \tag{1}$$

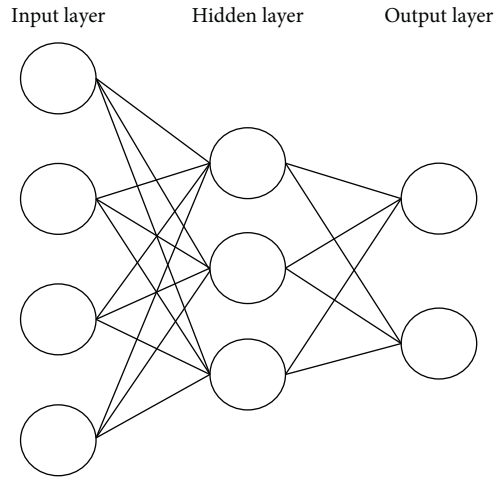

Figure 1: Basic structure diagram of neural network structure.

In the above formula, $a1, a2, a3$ represent three nodes of the input layer, respectively, W_{ij} represents the weight, and g is a nonlinear activation function, which mainly maps the weighted value nonlinearly. The final node in the above formula is obtained by continuously weighted summation and nonlinear transformation of the previous values. In addition, it is necessary to express the offset node. Let $A1, A2, T$ represent the transmission vector in the network, $W1, W2$ be the matrix parameter, and $B1, B2$ represent the offset vector. The mathematical expression of at this time is

$$\begin{aligned} A2 &= g(A1 * W1 + B1), \\ T &= g(A2 * W2 + B2). \end{aligned} \tag{2}$$

ANN is an adaptive and nonlinear information processing system composed of a large number of interconnected processing units, which is produced by trying to simulate the way of memory and processing information of neurons in the brain [23]. It is proposed on the basis of modern neuroscience research results. Its basic characteristics mainly include the following four points: nonlinearity, nonlimitation, very qualitative, and nonconvexity. Figure 2 is a schematic diagram of a typical M-P model.

It can be seen from the above model that the actual output of neurons in ANN is determined by input unit, connection weight, and threshold, and its output value can be regarded as a function of the three [24]. In practical applications, the input signal $X_i (X = 1, 2, \ldots, n)$ often appears in the form of a vector $X = (X_1, X_2, \ldots, X_n)^T \in R^n$, which is called an input sample. Generally, three excitation functions are obtained.

The excitation function of linear neurons is

$$f(X) = X. \tag{3}$$

The excitation function of threshold neurons is

$$f(X) = \begin{cases} 1, & X \geq 0, \\ -1, & X < 0, \end{cases} \tag{4}$$

About the excitation function of nonlinear neurons,

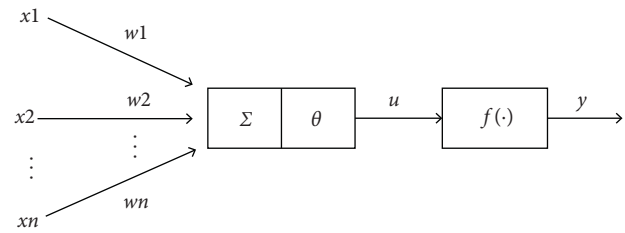

Figure 2: The basic model architecture of M-P.

$$f(X) = \frac{1}{1 + e^{-X}}. \tag{5}$$

2.2. Traditional Chinese Medicine Diagnosis Information and Data Processing. Artificial neural network is the abstraction of human brain neuron network. It is an operation model, which is composed of a large number of nodes (or neurons) connected with each other. Each node represents a specific output function, called the activation function. The connection between every two nodes represents a weighted value for the signal passing through the connection, which is called the weight. The output of the network varies according to the connection mode of the network, the weight value, and the excitation function. The network itself is usually the approximation of some algorithm or function in nature, or the expression of a logical strategy. There are intelligent programs that are specialized in specific fields, have expert level in this field, and can solve related problems in this field. Such programs are called expert systems. The development of ANN theory provides a new and effective way for medical intelligent diagnosis system. In traditional Chinese medicine diagnosis, the training is carried out according to the ANN samples, and the input values of the samples are uploaded to the nodes of the input layer. The ANN calculates and analyzes the received input values and weights and transmits the calculation results through the output layer. Once there is a deviation between the output mode and the sample mode, the ANN supports the adjustment of the network weights. In most cases, people regard expert system as a computer program in a specific field, which possesses the professional knowledge and experience in this field and can simulate the thinking mode of experts in this field and solve difficult problems that only some experts and scholars in this field can solve. The relationship of each part of the expert system is shown in Figure 3.

As can be seen from the above figure, the expert system consists of five parts: knowledge base, knowledge acquisition mechanism, comprehensive database, reasoning system, human-machine interface, and interpretation text system. Among these five components, the knowledge base and the inference engine are the core and the most difficult to implement, and they are also indispensable. The interpretation part and knowledge acquisition part may not exist in some special fields, but a perfect expert system should have the above five parts at the same time.

The knowledge and experience of domain experts are stored in a place called knowledge base. Machines cannot

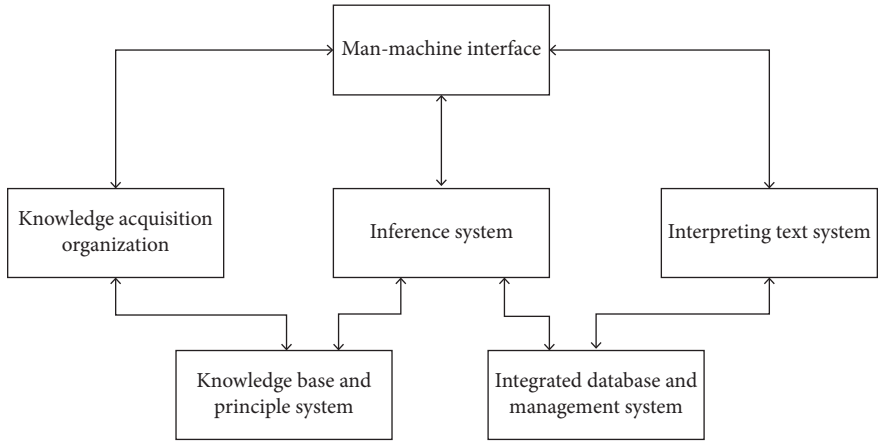

Figure 3: The relationship structure diagram of each part of the expert system.

understand human language, so the knowledge of experts needs to be converted into a machine language that can be understood by computers by using appropriate numerical values and symbols according to a rule combination, so that it can become the knowledge base of expert systems. The main criterion to distinguish whether a knowledge base is an intelligent knowledge base or a traditional knowledge base is whether the knowledge base is dynamic or static. During the operation of the expert system, domain experts can detect its running status, and when it is found that there are knowledge errors or omissions in the knowledge base, the knowledge base can be modified, added, or deleted. The theoretical basis of TCM diagnosis system is generally as follows: the meridian theory of TCM and the dialectical theory of Zang Fu organs. According to the syndrome differentiation theory of viscera in traditional Chinese medicine, the human body is essentially a set of control system, and the external performance of the human body is closely related to the condition of viscera in the body. By measuring the external manifestations of human body, such as impedance information, we can get the related problems of internal organs. It can be said that the external impedance information is the reflection of the internal viscera of human body. It is similar to using the degree of regional development to express the diagnosis, as shown in Table 1.

It can be seen that, for records with larger actual LRD values, the predicted values are relatively accurate, which is related to the distribution of individual cases in the diagnostic sample. Therefore, when training a neural network, the inclusion of the sample set should be fully considered.

Table 1: Application of LRD value in system analysis.

LRD value	Number of diagnoses recorded in the sample table	Precision of prediction (%)
LRD > 3.0	22	82
3.0 < LRD < 4.0	44	95
4.0 < LRD < 5.5	67	93
5.5 < LRD < 7.0	75	97
7.0 < LRD	20	97

2.3. Construction of Information Management Model and Algorithm Optimization. Usually, when developing TCM diagnosis information management system, we need to build a development model according to the needs of users and then develop the software system according to the model. When the fitness performance is equivalent, the individual with small structure size is preferred; for the hidden unit addition variation, only when the structural variation improves the weight evolution learning performance, the new individual with better performance will replace the worst performance of its parent individual, at this time indicating structural evolution. For hidden unit deletion variation, only when the structural variation does not reduce the learning performance of weight evolution, the new individual with better performance will replace the one with the worst performance of its parent, which indicates structural evolution. There are two main ways of development. (1) The latter development method: that is, firstly implement the informatization of an important diagnostic information, gradually expand the system functions on the basis of perfect functions, and then connect the various diagnostic information to each other until the diagnosis is realized. (2) Chain development mode: that is, first complete the informatization around a diagnosis process of TCM diagnosis information, and then gradually expand and improve to various diagnosis types until the informatization of the whole TCM diagnosis is realized. The mathematical models established by different development methods are also different. Figure 4 shows the basic schematic diagram of information management system.

The traditional Chinese medicine diagnosis information management system developed in this way also has obvious customization characteristics. It is not only not universal in different medical fields, but also difficult to transplant between different diagnosis types in the same field when the current software standards are not unified. Therefore, after long-term knowledge reserve and experience accumulation, a cross-domain management information system development platform based on ANN is proposed to solve a series of

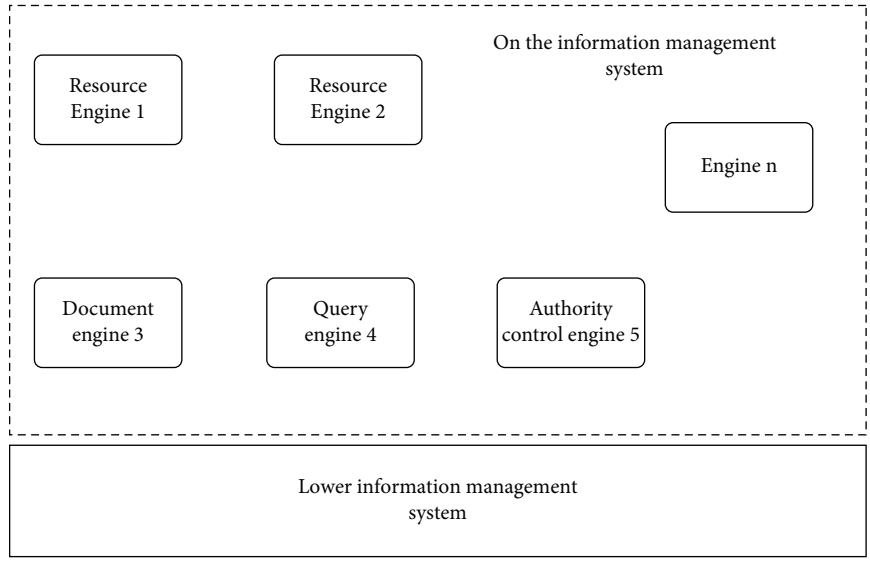

Figure 4: The basic principle diagram of the information management system.

thorny problems encountered in traditional customized development and strive to shorten the development time and reduce the development cost. The algorithm part of the information management system will be optimized below, so that it can be processed efficiently and accurately in actual operation.

From the above ANN algorithm, we can see that BP algorithm has the following characteristics. The learning process is composed of two processes. The weight adjustment process of each layer of signal forward propagation and error backward propagation is repeated. Generally, when the network output is not equal to the expected output, there will be an error, and its mathematical expression is as follows:

$$\begin{aligned} E &= \frac{1}{2}(D-Y)^2 \\ &= \frac{1}{2}\sum_{k=1}^{l}(d_k - y_k)^2. \end{aligned} \tag{6}$$

The definition of the above error is transferred to the hidden layer and calculated as follows:

$$E = \frac{1}{2}\sum_{k=1}^{l}\left[d_k - f\left(\sum_{j=0}^{m} w_{jk}h_j\right)\right]^2. \tag{7}$$

It is further expanded to the input layer and obtained by calculation:

$$E = \frac{1}{2}\sum_{k=1}^{l}\left\{d_k - f\left[\sum_{j=0}^{m} w_{jk} f\left(\sum_{i=0}^{n} v_{ij}x_i\right)\right]\right\}. \tag{8}$$

It can be seen from the above formula that the network input error is a function of the weights W_{jk}, V_{ij} of each layer, so adjusting the weights can change the error E. Obviously, the principle of adjusting the weight is to reduce the error constantly, so the adjustment of the weight should be proportional to the negative gradient of the error; that is,

$$\begin{aligned} \Delta w_{jk} &= -\eta\frac{\partial E}{\partial w_{jk}}, \\ \Delta v_{ij} &= -\eta\frac{\partial E}{\partial v_{ij}}. \end{aligned} \tag{9}$$

$j = 0, 1, 2, \ldots, m; k = 1, 2, \ldots, l, \quad i = 0, 1, 2, \ldots, n; j = 1, 2, \ldots, m$. The negative sign in the formula indicates that the whole gradient is downward, and the constant indicates the proportional coefficient, which reflects the diagnosis rate in the sample. In addition, in the design of knowledge base, it should be defined as $W = (U, R)$, where U is the domain and R is an equivalent relationship on U. Therefore,

$$\mathrm{IND}(B) = \left\{\left(X_i, X_j\right) \in (U \times U) \mid \forall a \in R, f\left(X_i, a\right) = f\left(X_j, a\right)\right\}. \tag{10}$$

Then, $\mathrm{IND}(B)$ represents the indistinguishable relationship of any subset B, and U/B represents all equivalence relationships of $\mathrm{IND}(B)$. At this time, there are two kinds of approximate definitions: one is the upper approximate definition, which is generally expressed as

$$R_{\_}(X) = U\left\{Y \in \frac{U}{R|Y \subseteq X}\right\}. \tag{11}$$

The other is the following approximate definition, which is generally expressed as

$$R^{-}(X) = U\left\{Y \in \frac{U}{R|Y \cap X} \neq \varphi\right\}. \tag{12}$$

Set $BN_R(X) = R^{-}(X) - R_{\_}(X)$ which defines the boundary domain with X as R. Based on this, in order to speed up the accurate correction of weights, the improved BP algorithm adds an iterative term $\alpha\Delta W_{ij}(k)$ to the

formula, which is equivalent to providing a momentum category in the weights and effectively filtering out the high-frequency variables of the error surface of the weight space, as follows:

$$\Delta W_{ij}(k+1) = \eta\delta_i x_j + \alpha\Delta W_{ij}(k),$$
$$\alpha = \begin{cases} 1.7, & \delta_i(k+1) < \delta_i(k), \\ 0.7, & \delta_i(k+1) < \delta_i(k), \end{cases} \tag{13}$$

where α represents the relaxation factor, $\Delta W_{ij}(k+1)$ represents the correction of the weight in the next cycle, and $\Delta W_{ij}(k)$ is the correction of the weight in the previous cycle. Therefore, the above formula can be regarded as a first-order difference equation. When the parameters are of the same sign, the weighted sum value increases. At this time, the stable adjustment increases the adjustment speed of the weight. If the sign is opposite, it indicates that there is oscillation. At this time, the exponential weighting and the result will be reduced, which has a stable effect.

3. Result Analysis and Discussion

At present, the computer system using CPU + GPU hybrid computing mode has the ability to train neural network. In order to establish a scientific, feasible, and efficient TCM diagnostic information management system, this paper further conducts experimental analysis on the basis of the above research and analysis, so as to strengthen the confirmation of the reliability of the system design and observe whether the system can be used in actual operation and whether the diagnosis information of traditional Chinese medicine can be well managed. Therefore, this paper will analyze and judge from several important indicators, such as average error, fitness value distribution rate, information accuracy, and node prediction accuracy. Figures 5 and 6 are the analysis charts of average error and fitness values on sample sets A, B, and C.

When the number of nodes in the hidden layer is A, B, and C, after N iterations, the change of the mean square error of the model is shown in Figure 6, in which the vertical axis represents the mean square error after each iteration, and the horizontal axis represents the number of BP neural network fitting iterations. When the overall error is less than 0.4 or the number of iterations reaches the maximum, the training ends. After N iterations of training, the training of the model is terminated due to excessive parameters. It can be seen from the figure that, in the n training process, the mean square error after the A, B, and C iterations is 48.7%. The cross-validation result at this time is the best, and the overall error of the system is reduced by about 75.3% after optimization. Through the above algorithm to train the disease diagnosis model based on BP network, the fitness value increases obviously after n times. After several searches, the fitness of the system tends to be stable. The most stable situation is when the distribution rate remains around 65%. Let Q and M be two sample sets of TCM diagnostic information for experimental analysis in terms of information accuracy and node prediction accuracy. The data analysis diagrams are shown in Figures 7 and 8.

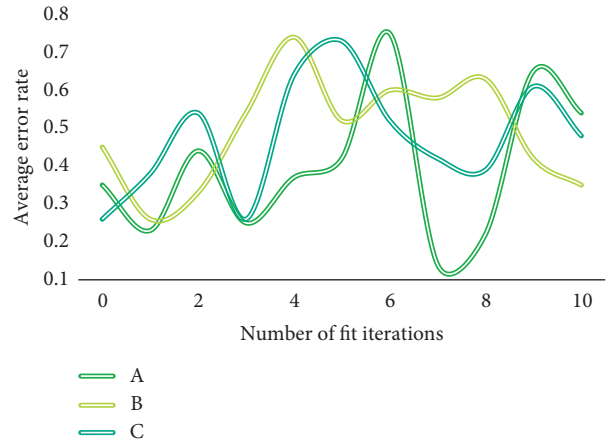

Figure 5: Average error analysis diagram.

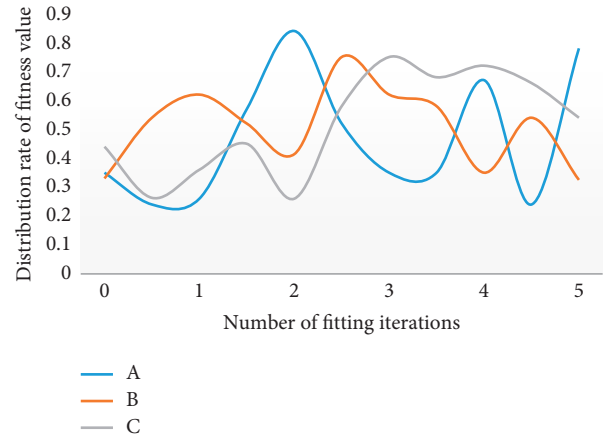

Figure 6: Analysis of fitness value distribution rate.

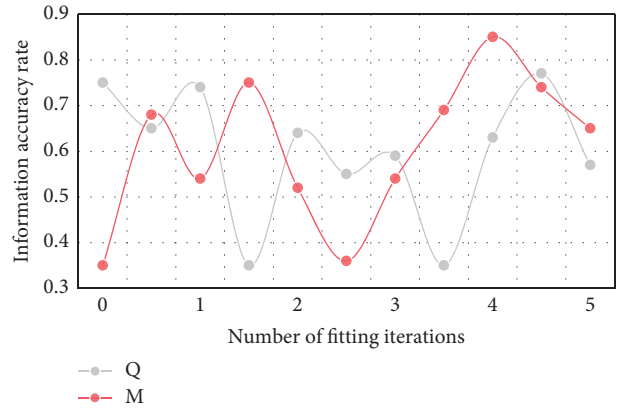

Figure 7: Information accuracy analysis diagram.

Because the accuracy of information determines the reliability of the management system, attention should be paid to the screening of information. Therefore, this paper designs this part in the experimental part. After inputting the data, it is found that due to the lack of a complete information chain and analysis mode in the early input of diagnostic information, there is a large fluctuation between

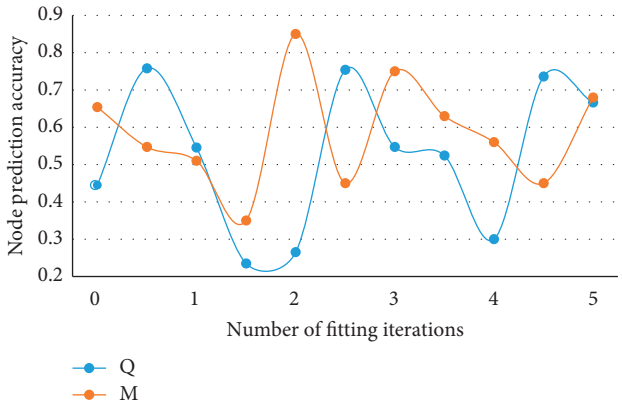

Figure 8: Analysis of node prediction accuracy.

different sample sets. However, as the number of iterations continues to increase, the results will obviously increase or decrease with the same trend, which also indicates that the stability of the system designed in this paper is optimized, and it basically keeps increasing after interval 3-4, with the growth rate basically keeping at the average level of 68.4%. It can be seen from Figure 8 that the prediction accuracy of the BP neural network is the highest when the hidden layer node is 2, which is 85%. The training time is the lowest when the hidden layer node is the least, which is 3 seconds. The analysis shows that the number of hidden layer nodes will have a certain impact on the prediction accuracy, but there is little difference in prediction time. Considering the application environment, it should be considered to select 2 with high prediction accuracy as the number of hidden layer nodes, with an accuracy of 75%, which can meet the performance requirements of the application.

4. Conclusions

This paper combines the strong learning ability, strong adaptability, and large-scale parallel processing ability of ANN to solve the nonlinear and unstructured complex problems in management information system and designs and develops the optimization of traditional Chinese medicine diagnosis information management based on ANN. Further rapid development, with the support of ANN and various information technologies, improves the intelligent degree of traditional Chinese medicine diagnosis, provides technical support for the development of traditional Chinese medicine, and promotes the healthy and long-term development of traditional Chinese medicine. Through the combination of natural language processing technology and data preprocessing methods, this paper screens and processes chaotic medical data, including Chinese word segmentation of medical data, research on the correlation of medical symptoms, and quantitative processing of Chinese data, which are different from traditional data processing, and mines semantic information of symptoms and diseases by training symptom word vectors. The process and characteristics of the related neural network algorithm, evidence combination theory, and association algorithm are sorted out and briefly described, and an optimized neural network algorithm is established. After the experimental analysis, it is found that the overall error of the optimized system is reduced by about 75.3%, the distribution rate is the best when it remains at about 65%, and the growth rate is basically maintained at the average level of 68.4%. In terms of node prediction accuracy, considering the application environment, the average accuracy is 75%, which can well meet the performance requirements of the application. However, this study still has some limitations. In terms of node prediction accuracy, it seems that different application environments are not considered. This needs to be further explained in future research.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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