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An AHP-GA-BP Algorithm for Evaluation of Enterprise Collaborative Innovation Management of Intellectual Property Rights

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Abstract

Based on the theory of BP neural network, we use AHP method to construct the index system and standard of enterprise collaborative management of intellectual property rights under the view of innovation, and the specific evaluation indexes are given from five aspects. In this paper, in order to overcome the existing shortcomings of multi index system In the evaluation method, we use AHP-GA-BP neural network to comprehensive evaluation each index of enterprise intellectual property management. Our method not only displays the evaluation expert experience in learning The evaluation results show that this algorithm can effectively analyze enterprise intellectual property management problems.

Keywords: *collaborative innovation evaluation, intellectual property rights, BP neural network, genetic algorithm, AHP*

1. Introduction

The field of innovation was focused on understanding such issues as the rate and direction of technical progress (at both industry and national levels), the sources of innovation and a lot of questions about the organization and management of R&D. In the mid-1980s, the strategy field was being transformed by Michael Porter's seminal work on the competitive forces [1]. Strategy was focused on understanding the implications of industry structure on competitive choices and positioning. Innovation did not play the role of a "central actor". Cooperative innovation is a method that established by the original innovation and used the collaborative innovation center as the carrier. It is based on the innovation of mechanism and systems that take the ability of disperse to the cluster ability to solve the major problems. In order to mobilize all the main talent, capital, information, technology and other aspects of the activity, we must keep to the principle of fair and reasonable.

Carrying out collaborative innovation can enhance cooperation between universities, research institutes, enterprises and foreign research institutions. To speed up the integration and reorganization of scientific and technological resources, promote the talent innovation inspiration collision with different professional background and practice, and improve the efficiency of innovation are advantageous to overcome the major national research project. It also helps to achieve substantial scientific and technological achievements in the field of

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national key technology, and make great contributions to the construction of innovative country. Beyond all doubt, collaborative innovation has the great significance of improving the industrial competitiveness, formatting the new economy and promoting the development of innovation.

For example, the net present value method [2] and interpolation method are both commonly used method of technical and economic evaluation [3]. Because many evaluation indicators have been beyond the scope of economic factors, the technical and economic evaluation method can not complete the assessment of collaborative innovation ability of enterprises separately. The multi-factor evaluation is a kind of statistical analysis method. It most commonly uses the weight to depend on the expert experience of multi-level index value weighted comprehensive evaluation method [4], regression analysis method [5, 6] and the structural equation modeling method [7]. There also are some non-statistical analysis method including benchmarking [8,9], multi-level and multi factor comprehensive and balanced score card [10], data envelopment analysis [11], system dynamics [12, 13] and artificial neural network [14, 15].

In our approach, the genetic algorithm is used to optimize BP network topology, and then decomposition approach is applied to extract rules in disjunctive normal form the optimized and trained BP network. This paper is organized as follows. Section 2 and Section 3 describe the AHP theory and genetic algorithms, respectively. Section 4 introduces the activation function of BP network. The new method called AHP-GA-BP model is proposed in Section 5. Section 6 presents the simulation results, and conclusions are summarized in Section 7.

2. The AHP Theory

In general, the selection of alternatives is a multi-criteria decision making (MCDM) problem. Till now, many MCDM methods for selecting/evaluating alternatives have been developed [16-21]. The analytic hierarchy process (AHP) proposed by Saaty [22] is a widespread decision-making analysis tool for modeling unstructured problems in areas such as political, economic, social, and management sciences. Based on the pair-by-pair comparison values for a set of objects, AHP is applied to elicit a corresponding priority vector that represents preferences. Since pair-wise comparison values are the judgments obtained using a suitable semantic scale, it is unrealistic to expect that the decision-maker(s) have either complete information or a full understanding of all aspects of the problem [23-27]. Due to the real situations in which information is incomplete or imprecise, the views are subjective or expressing with linguistic characteristics creating a decision-making environment [28].

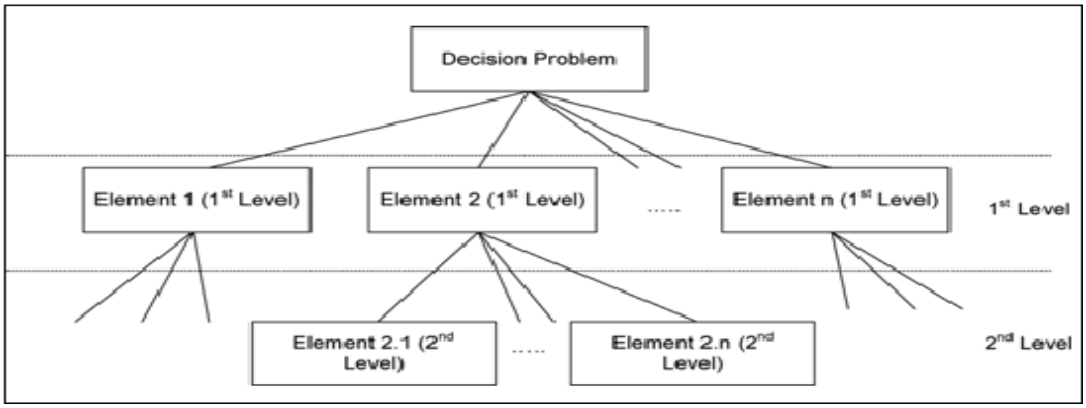

Figure1. Indicative Two-level AHP Hierarchy

AHP is regarded as a popular method for organizing complex decisions. The conversion of judgments into numerical values is based on a pair-wise comparison matrix for criteria $C=\{C_1, C_2, ..., C_n\}$, as shown in following matrix.

$$\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{12}^{-1} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n}^{-1} & a_{2n}^{-2} & \cdots & 1 \end{bmatrix}$$

where a_{ij} represents the pair-wise comparison of criterion i over criterion j, on an 1-9 scale, where 9 indicates a strong preference towards criterion i, and 1 means no perception of difference between the two criteria (shown in Table1). The matrix shown in Table1 is completed based on group decisions, and weights are derived after a straightforward mathematical procedure. Also, this matrix is checked for consistency and its contents are revised, if necessary, by the group.

Table1. Matrix scale and its Meaning of AHP

Intensity of importance	Definition
1	Equally important
3	Moderately
5	Strongly
7	Very
9	Extremely
2,4,6,8,	Intermediate

3. Genetic algorithms

Genetic algorithm is a kind of random search method which is evolved from the biological evolution law (survival of the fittest, the fittest genetic mechanism of the survival). It was first proposed by Holland in 1975 [29].The simple genetic algorithm is one of the most basic genetic algorithms which are summed up by Goldberg [30]. The genetic operation process is simple, easy to understand. It is the prototype of some other genetic algorithms. The basic step of genetic algorithm consists of initialization, evaluation the fitness of individuals in population, selection operation, crossover operation, and mutation operation and termination judgment.

Genetic algorithm has a good performance to solve combinatorial optimization problems. Miehalewiez proposed the operator of Inver-over which combines a crossover operator and mutation operator [31]. The operator makes full use of the population information to guide the population evolution in the process of search space. Many researchers have proposed to improve the performance of genetic algorithm. Rudolph proposed that keeping the best individual in a group is not lost with elitist selection strategy, in order to ensure the convergence of the algorithm [32]. Wang put forward a new genetic algorithm for solving traveling salesman problem through the hybrid crossovers, and gives the verification of experimental [33]. With some modifications of the genetic operators, the real-coded GAs performs better than the binary-coded GAs for TSP. The crossover operator of a real-coded

GAs is performed by the borrowing concept of convex combination. The random mutation operator is used to change the gene with a random number in the problem's domain [34, 35].

BP neural network is also called the neural network of error back propagation, which is composed of input layer, output layer, and hidden layer. First of all, the information of the external environment is input to the input layer neurons of neural network, and it is transmitted to the hidden layer neurons. Secondly, after processing the information transform, information is transferred from the hidden layer to the output layer. Then, the results will output from the output layer by the further treatment. Thus, the neural networks have completed an information processing.

4. Activation function of BP network

The excitation function is one of the main factors that determine the performance of neural network. If the excitation function of neuron is different, it will make the neurons with different mathematical models, which have different characteristics of information processing. Therefore, the correct selection of excitation function is very significant. There are many kinds of excitation function for the optimization model of intellectual property right management. Excitation function including threshold transform function, nonlinear transformation function and linear transformation function.

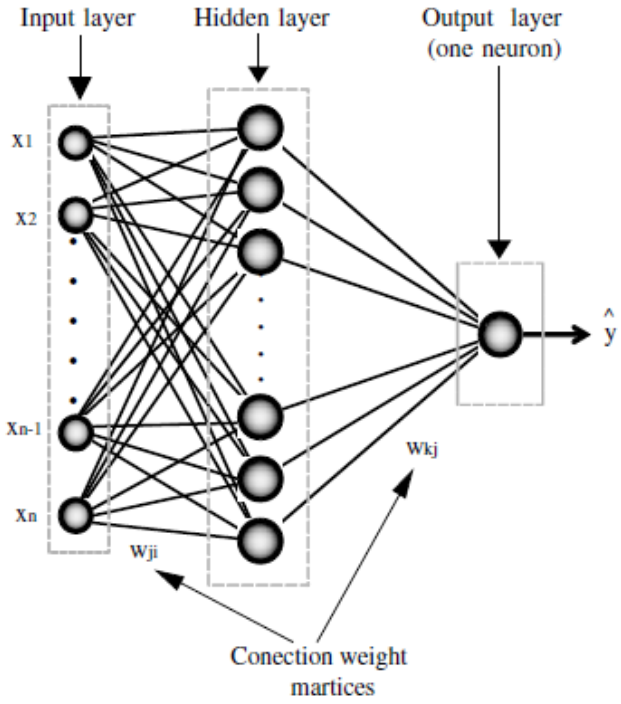

Figure 2. A Typical Structure of Three Layer BP Network

The concrete expressions are as follows:

(1) Threshold transform function

$$f(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x \leq 0 \end{cases} \quad (1)$$

(2) Nonlinear transformation function

Nonlinear transform functions commonly used for sigmoid function curve of unipolar, referred to as *S* type function. The *S* type function and its derivative are continuous, so the data processing is very convenient. The unipolar *S* function is also called log sigmoid function; the function expression is shown as follows:

$$f(x) = \frac{1}{1 + e^{-x}} \tag{2}$$

(3) Linear transformation function

The characteristics of the function are the neuronal input and output satisfies the linear relationship in a certain range. The linear function is shown as follows:

$$f(x) = kx \tag{3}$$

In order to ensure that intellectual property right management optimization model of BP network can training and learning the nonlinear relationship between the input and output. The hidden layer is selected the tangent S function.

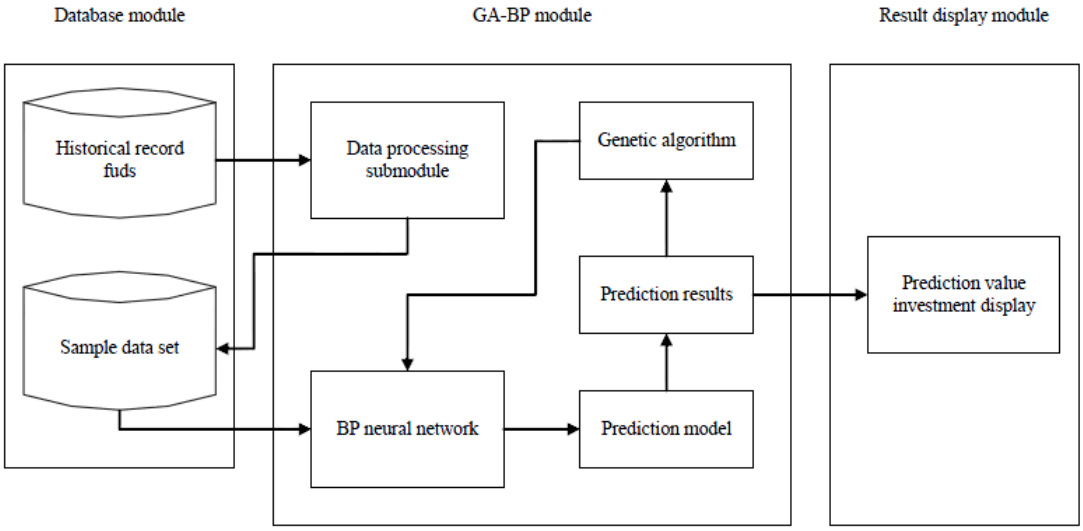

Figure 3. The Forecast Model Module Chart

GA-BP neural network structure is finally construct the predict model to solve the regression problems. According to years of research, it is found that the two training parameters of weight matrix and BPNN threshold can directly influence the BPNN final prediction accuracy [6]. Therefore, genetic algorithm is needed to search the weight matrix and iteration threshold value, in order to improve the prediction precision BPNN. Forecasting model is made up of three modules, which are display module, GA-BP module and database module. Among them, the database module mainly responses for the storage investment funds of electric power industry records of each year in history and in accordance with the time sequence of the generation of sample data set method; the results show that the module is responsible to show prediction results of the loan to users. The date flow of the composite prediction model and structure is shown in figure3, and the AHP–GA-BP network model flow chart is shown in figure4.

5. The AHP-GA-BP collaborative innovation evaluation model

5.1. The characteristics of collaborative innovation

Collaborative innovation system is the innovative scheme that is composed of two or more than two customers and the development of the enterprise staff working together. It thought the information exchange and coordination mechanism with the computer and network support. Characteristics of cooperative innovation system are shown as follows.

(1) Coordination and conflict

Cooperation is the basic characteristics of collaborative innovation. Different people take different parts of innovation work reach a common goal; On the other hand, collaborative innovation personnel in different majors and different background will inevitably cause conflict between personnel.

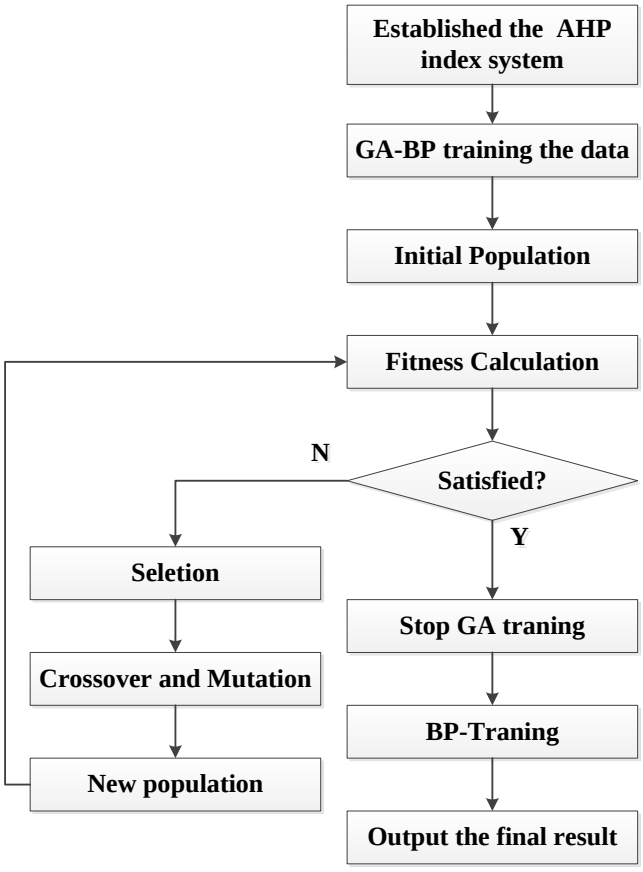

Figure 4. Genetic Algorithm - back Propagation Flow Chart

(2) Distribution

The collaborative innovation personnel is distributed in the region. We complete the design task by computer network and collaborative platform in their respective fields.

(3) Dynamic

In the collaborative innovation process, the progress of the work, the deployment of personnel, the allocation of resources and conflict is dynamic occur. So, the collaborative innovation has dynamic characteristics.

(4) Synchronous and asynchronous.

Some tasks done in real-time which requires synchronization in the collaborative innovation process; On the other hand, some do not need to work in real-time that use asynchronous operation mode can be completed, such as e-mail. Therefore, collaborative design has the characteristics of synchronous and asynchronous.

(5) Stage and recurrent

Collaborative innovation work is carried out step by step, so it has a stage; At the same time, innovation is not can be successfully completed at once, it must obtain the optimal design scheme through repeated modification.

5.2. The AHP-GA-BP index system

According to the character, integrity, scientific, importance and equilibrium principle and system design requirements in the system, the evaluation system of collaborative innovation and its indicators are established, as shown in Table 2.

Table 2. Evaluation Index System of Intellectual Property Rights Classified

Classified	Index
1.The intellectual property rights consciousness (C1)	(C11). the proportion of enterprises which has more than 1 pieces of patent (C12). the patent applications for every ten thousand person (C13). the volume of trademark applications for every ten thousand person
2.intellectual property protection (C2)	(C21). the administrative protection index of intellectual property rights (C22). the judicial protection index of intellectual property rights (C23). the number of patent of collaborative innovation
3.the input of intellectual property (C3)	(C31). Intellectual property investment accounted for the proportion of fiscal expenditure (C32). Intellectual property budget accounted for the proportion of the total budget in technology project (C33). Patent agents accounted for the proportion of the patent application (C34). Management of patent intellectual property rights accounted for the enterprises
4.the onput of intellectual property (C4)	(C41). Possession of valid patent for every ten thousand person. (C42). the number of invention patent for every ten thousand person. (C43). the growth rate of invention patent (C44). the registration of a trademark for every ten thousand person.
5.The use of intellectual property rights (C5)	(C51).Fluency working process (C52).Reasonable work process settings (C53). Instantaneity for conflict resolution in work process

6. Simulation

Because of the meaning various indicators, measuring dimension and quality standards are not the same. In order to comprehensive evaluation to multi index of evaluation object, we reverse index, interval index and appropriate index, according to the need for positive and

dimensionless treatment. This process is called the index value standardization. It is the essence of the no addition or multiplication index into the comprehensive index that can be aggregated addition or multiplication value. After standardization of the index value, the results of comprehensive evaluation are calculated according to the evaluation index model. The index values are quantized by a scale with four grades. The quantization model with four grades is applied in index system, as shown in Figure5.

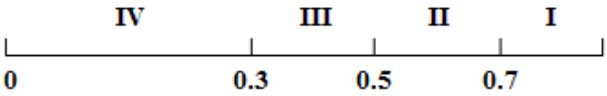

Figure 5. The Quantification of Qualitative Indices

The BP neural network evaluation improvement is use the genetic algorithm model to evaluate the collaborative innovation management. The program codes were written in MATLAB. The Tansig function is used as the neuron transfer function of BP network hidden layer, namely the tangent function of S type. Because the target output value of BP network output layer which is 1, 2, 3, 4 and 5, the use of purline pure linear function as the transfer function of output layer neurons. The index layer as the input value of layer neuron that from (C11) to (C53). LM algorithm is used for training samples, which namely trainlm function. The training rate is set to 0.5, the expected error is one in a million, and the largest network of training time is set to 300.

After the training, it is found that the mean square error of BP network reaches the minimum value when hidden layer node is 10, as shown in Figures 6 and 7. Then, several cases of six main types of enterprises are applied to evaluate the intellectual property and collaborative innovation, which are composed of the industrial enterprise (A1), transportation enterprise (A2), real estate enterprises (A3), computer services and software company (A4), information transmission enterprises (A5) and the business and technology services company (A6).

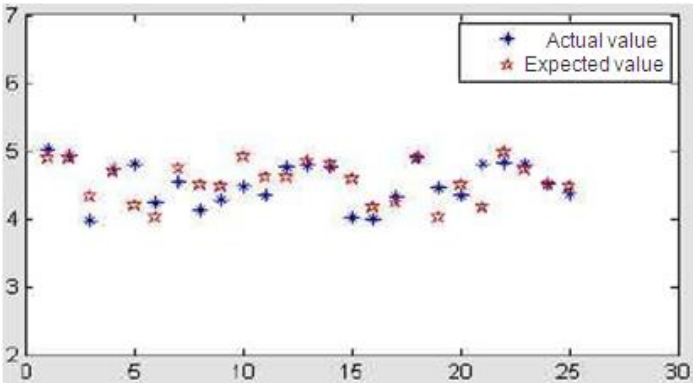

Figure 6. Output Value of BP Neural Network that the Node Number is 10 and the Mean Square Error is 0.0812

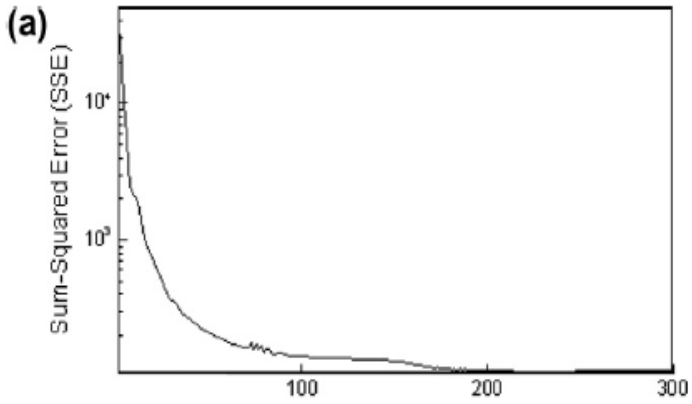

Figure 7. Variations of the Sum-Squared Error in the Training Process

The evaluation results and grades of different enterprises are shown in Table 3 and Table 4, respectively. From Tables 3 and 4, it is clear that the degree of attention of enterprises is different in the intellectual property rights and collaborative innovation. In terms of inputs and outputs of the intellectual property, the information transmission enterprises is the best. Because the information technology is the most rapidly developing technology. To strengthen the protection of intellectual property rights is an important measure to ensure the monopoly and win market opportunities.

Table 3. The Evaluation Results of Different Enterprises

	A1	A2	A3	A4	A5	A6
C1	0.43	0.33	0.35	0.55	0.71	0.52
C2	0.51	0.44	0.42	0.57	0.75	0.61
C3	0.42	0.27	0.44	0.62	0.68	0.48
C4	0.34	0.35	0.33	0.71	0.77	0.39
C5	0.41	0.51	0.18	0.48	0.51	0.55

Table 4. The Evaluation Grades of Different Enterprise

	A1	A2	A3	A4	A5	A6
C1	III	III	III	II	I	II
C2	II	III	III	II	I	II
C3	III	IV	III	II	II	III
C4	III	III	III	I	I	III
C5	III	II	IV	III	II	II

7. Conclusion

In this paper, we proposed an improved hybrid evaluation model consisting of genetic algorithm, BP neural network and AHP (AHP-GA-BP), to enhance the performance of established evaluation model for enterprise collaborative innovation of intellectual property

rights. The AHP-GA-BP model can effectively overcome the drawbacks of BP neural network that randomly selects weight and threshold, and this method has better search ability. And, an evaluation model based on AHP is constructed according to the characteristics of collaborative innovation.

Research institutions and many universities have been established with the intellectual property administrative agencies. Enterprises need a high level talent team which has the reasonable knowledge and ability. It can form the relative standard process of intellectual property rights management. In order to strengthen the management of intellectual property of enterprises in our country, we should learn from foreign experience to formulate relevant policies. The establishment of intellectual property system, we can optimize the management mode and cultivate the intellectual property management talent.

In order to make the quantitative analysis more scientific, we will conduct in-depth analysis of the establishment of intellectual property system of quality control in the future research. At the same time, we will also consider the research content of improve enterprise innovation ability and intellectual property evaluation index system.

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