

## Research Article

# Machine Learning-Assisted Competency Modeling for Human Resource Management Jobs

Changfang Cao and Zhongying Zhang 

*School of Management Engineering, Anhui Institute of Information Engineering, Anhui, Wuhu 241000, China*

Correspondence should be addressed to Zhongying Zhang; 2016039@aait.edu.cn

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The competency model has an important role in human resource management (HRM) as a scientific and objective talent assessment theory. With the widespread use of machine learning methods, machine learning assistance for HRM job competency assessment and determination provides a new way of thinking for talent assessment and management. The establishment of HR competency models based on machine learning methods can quickly and accurately help companies gain a competitive advantage. Based on this paper, we take Company C as the research object and establish the HR management job, competency model, based on a genetic algorithm optimized BP neural network (GA-BP). The results show that the model can be better applied to the analysis of the HR management job competency model of Company C. The prediction accuracy reaches 91.16% classification accuracy, which has a certain reference significance, and it has a certain reference and value for the HRM job industry.

## 1. Introduction

With the rapid development of computer technology, the trend of information diversification is increasingly obvious, and the competition between enterprises is more intense. In order to gain more competitive advantages, enterprises must grasp the strategic resources of human resources, play the core role of human resources management in the development of enterprises, and the recruitment management system must be constantly reformed to mature. Recruitment management is the basic work of an enterprise, which will have a significant impact on the management and operation of the enterprise [1–4]. How to solve the above problems requires HRM positions to focus on.

Facing cruel business competition, the survival of enterprises is closely related to the choice of talents. It can even be said that the healthy and sustainable growth and development of enterprises depend on screening potential talents and cultivating talents. Managers' competence is not static. Different times and different business environments have great differences in the requirements of enterprise

managers' competence. The real environment has different requirements for managers' competence. As managers, they must dynamically adjust to meet the actual needs in order to remain invincible in the fierce competition. On this basis, how to measure whether employees are competent is an important part of talent search and training. It can be said that the relevant topics of talent competency are not only the subject of HRM but also a major issue to build the company core competitiveness, which is closely related to the company's short-term goals and long-term blueprint. Enterprises must properly measure the ability of employees, ensure that employees are delivered to different positions required by the company with high quality, and improve the adaptability of the company in the current unpredictable market competition environment. However, in fact, most companies do not really realize the importance of employee competency and do not attach importance to the assessment of employee competency. Job allocation is usually relatively reluctant, which may eventually lead to project failure or brain drain. Certainly, some companies have a clearer understanding of the importance of employees, but when evaluating and judging employees, they often focus only on

obvious and objective aspects, such as their work experience, education, objective skills, and technology. Employees' life values, job motivation, personal will, their own characteristics, and the degree of job matching have not been in-depth exploration and understanding [5, 6]. In addition, some companies can only rely on years of human resources experience, interview experience, and managers' personal feelings when evaluating and judging employees, which will affect their work. It can be imagined that the results of human resources work have some effect, but not comprehensive. In general, employees are the spirit of the enterprise, evaluation, and judgment of employees is an important part of the healthy development of enterprises. The evaluation and judgment results directly determine the success or failure of the company's operation. The adverse circumstances listed above will lead to higher costs and greater employment risks, which to some extent affect and limit the normal development of the company.

From a realistic perspective, in the case of a sharp increase in the demand of employees in the company, the management position based on the competency model is of great significance. The society has devoted a wide range of attention to HRM positions, so that a variety of management models are derived and applied to the actual business management [7–9]. At present, the competency model is widely used internationally, and the competency model is more biased towards practical ability, which can help enterprises to improve recruitment efficiency, recruitment system more scientific and complete, and create a long-term strategic layout.

Competency model research has a long history. The concept of competency began in the United States in the early 1970s and has been widely used in Britain and other countries. After the concept of competency model is put forward, it has attracted great attention from the business community and academia and has become the focus of global management research. Feng Ming and Yin Mingxin systematically summarized the construction methods of competency model, including behavioral event interview method, functional analysis method, scenario method, performance method, and multidimensional method. Xu Feng analyzed the importance of competency model from the perspective of human resource performance management and proposed methods such as behavioral event interview and human resource index analysis. In the 1990s, the Hong Kong Management Development Center of China used the competency method to train and develop local managers [10, 11]. They used literature review and brainstorming to obtain 30 competency items of middle-level managers. Through the investigation and study of more than 2000 middle managers, Hong Kong Management Development Center has obtained several management competency groups: leadership, communication, team member spirit, team building ability, result orientation, individual driving force, planning ability, efficiency, business consciousness, decision-making ability, customer orientation, and management competency factors have corresponding behavior description. Wang Jicheng put forward several general models of competence in his master's thesis (1)

professional and technical personnel model includes: achievement desire, influence, analytical thinking, initiative, self-confidence, interpersonal insight, information seeking, technical expertise, teamwork, and customer service awareness; (2) salesperson model includes: influence, desire for achievement, initiative, interpersonal insight, customer service awareness, self-confidence, public relations, analytical thinking, conceptual thinking, information seeking, authority awareness, related technology, or product expertise; (3) community service personnel model: influence, development subordinates, interpersonal insight, self-confidence, self-control, personality charm, organizational commitment, technical expertise, customer service awareness, teamwork, analytical thinking, initiative, development of others, self-confidence, command, information seeking, team leadership, conceptual thinking, county-wide ownership, public relations, and technical expertise; and (4) entrepreneur model: desire for achievement, initiative, opportunity capture, persistence, information seeking, quality and credibility awareness, systematic planning, analytical thinking, self-confidence, professional experience, self-education, influence, command, development of subordinates, and public relations.

In 1978, Gug divided competence into concept competence, interpersonal competence, and skill competence. In 1982, Richard Boyatzis believed that competency model is related to personal performance, which may be transformed into motivation, personality, technical ability, personal image, social role, and knowledge body. In 1984, Stuart E. Dreyfus and Hubert L. Dreyfus proposed that the competency level is divided into five levels, according to different objects using different development methods. In 1993, Lyle M. Spencer and Sige M. Spencer believed that employees' ability-based selection methods should be based on the following assumptions: the more employees' ability meets the job requirements, the higher job performance, and satisfaction. A person's successful adaptation to work depends on (1) accurate evaluation of personal ability; (2) ability model for a given job; and (3) assessment methods to maintain a good balance between people and work. Peter Drucker put forward three hypotheses of business success, emphasizing that the necessary competence of employees to complete organizational mission is the most important one, and it is the fundamental premise to achieve business environment and organizational mission. In 1995, Lcdford believed that competence includes individual unique qualities, which can confirm clearly shown elements and the possibility of performance. In addition to focusing on the current performance, it also needs to focus on future performance. In 1996, Semark a British scholar argued that effective behaviour required by jobs was more important than potential factors. The general industry competency model is questioned and requires improvement in practice. In 2000, Nilan and Alldredge constructed the competency model of 3M company and extended it to the general competency model of administrative staff. In 2008, Peerasit proposed that in addition to knowledge and skills, core competence is also an indispensable factor for project managers [11–14].

In general, the establishment methods of competency model generally include induction and reasoning. Inductive method is based on the current position using the key sample method or behavioral event interview method for statistical analysis of the in-service staff, through the way of induction or brainstorming summarizes the quality characteristics and skill levels have a positive impact on job performance, based on specific behavior, develop competency model. The competency model established by the interview method is closer to the actual situation of the enterprise and is more suitable for mature and stable enterprises. However, the establishment process is time consuming and labor intensive, the operation is difficult, and the established model is not theoretically deduced, which often has certain limitations. Reasoning method is to deduce the competency model through the company's mission vision, core values, roles, and responsibilities of each position. The derivation process of the model can be completed by the company internal and can also be completed by external professional consultants. This method makes the model logic clear by considering the company's strategy and subdividing job responsibilities globally [15–17]. However, due to the lack of specific behavior as the basis, the description of the model may be too vague. With the rapid development of machine learning and artificial intelligence technology, the extensive and in-depth study of competency provides a new direction for the future development of human resources management.

Based on this, this paper mainly combines machine learning algorithm to establish a new competency model of HRM posts. Through literature survey, questionnaire survey, and time interview analysis, a large number of basic research data are collected and sorted out. Combined with the internal HRM database of a Chinese enterprise management post, we further sort out and eliminate the invalid data that are not completely filled out or filled out with obvious problems, which lays the foundation data for the case study. Then genetic algorithm is used to optimize BP neural network, and finally the competency model of HRM based on GA-BP neural network is established to realize the intelligent evaluation of the overall competency of managers.

## 2. Concepts and the Features

*2.1. Competency Concept.* In the process of carrying out performance management and human resource management, enterprises must combine their own actual situation to build a scientific and perfect service system.

The concept of competency can be traced back to the 1970s. In 1973, David C. McClelland, a professor of Harvard University, published "Testing for Competence Rather Than for Intelligence" in the *Journal of American Psychologists* [18–20]. He pointed out that the abuse of intelligence tests, sexual tests, academic tests, and grade scores to determine the irrationality of individual competence and proposed to replace the traditional intelligence measurement with competence, trying to find out the most obvious differences between the best performers and the average performers. The publication of this article marks the

beginning of competency research. Since then, many scholars have devoted themselves to the study of competency and put forward the definition of competency from different perspectives, as shown in Table 1.

Competency refers to the deep-seated characteristics of individuals who can distinguish outstanding achievements from ordinary people in a job. In recent years, with the improvement of the theoretical level and practical ability of HRM in China, the concept of competency model has also been improved. Its specific meaning is a position in an organization or enterprise, according to its responsibilities and requirements, the centralized representation of the ability support elements needed to complete the work, generally includes the following aspects: (1) professional skills: professional skills are required by the incumbent, so that the staff can skillfully operate the business process of a position, play its unique advantages and creative potential, and can be competent for the job requirements of a position. Employee competence refers to a person's unique knowledge, skills, and personality. It is a unique skill and personality psychological characteristics compared with other personal characteristics on the basis of specific post competency elements. (2) Professional knowledge: it requires the incumbent to master a certain depth and breadth of knowledge related to their own fields, can accurately analyze the problems encountered in the research work, make the right choice, and have the necessary professional technical level or management experience. (3) Professional ethics: it requires people engaged in an industry to meet the basic requirements of the industry and society in terms of ideology, consciousness, and will. (4) Practical ability: it means that the incumbent can apply the learned operating skills to practical work.

In order to improve the competitiveness of enterprises, continuously improve the competency model of the enterprise. The basic evaluation index of competency model is the comprehensive quality of a position. Quality refers to the deep characteristics that distinguish people with outstanding achievements from those with general achievements in a certain work. In the quality dictionary, psychologists divide people's quality into six groups (achievement and action group, help and service group, impact and influence group, management group, cognition group, and personal efficacy group) with a total of 20 specific elements. The elements are divided into many levels, making a comprehensive summary of human knowledge, skills, social roles, self-concept, personality, and motivation, and forming a complete quality model for enterprise employees.

*2.2. Characteristics and Classification of Competency Model.* Quality refers to the deep characteristics that distinguish people with outstanding achievements from those with general achievements in a certain work. In the quality dictionary, psychologists divide people's quality into six groups (achievement and action group, help and service group, impact and influence group, management group, cognition group, and personal efficacy group) with a total of 20 specific elements. The elements are divided into many

TABLE 1: Competency definition summary.

Scholars or institutional research	Definition of competency
Davld. C. McClelland	Knowledge, skills, abilities, traits, or motivations directly similar to or related to work or work performance or other important achievements in life
Richard Boyatzis	A person has the potential characteristics that lead to good performance in a job (it may be motivation, trait, skill, self-image, or social role, or the knowledge entity he uses, etc.)
Lyle. M. Spencer	Potential personal characteristics related to effective or excellent job performance, including five dimensions: Knowledge, skills, self-concept, traits and motivation
Flei Shman, Wetrongen, Marshall-Mies	A mixture of knowledge, skills, abilities, motives, beliefs, values, and interests
Mirabile	Knowledge, skills, abilities, or characteristics associated with high performance in a position
Dubois	Competency is the necessary ability to achieve or exceed the expected quality level of work output: it is the potential characteristics of an employee, such as motivation, skills, self-image, social role, and knowledge. These factors will lead to effective or outstanding performance in the work
Spencer	Individuals have one or more potential traits, and these potential traits are related to their job or job performance, but also can be expected to reflect their behavior and performance.
Green	Written description of measurable working habits and personal skills used to achieve work objectives
Boyatzis	A person's potential characteristics, such as motivation, traits, skills, self-image or social role, or the knowledge entity he/she uses, will produce effective or excellent job performance
McLagan	Competency refers to knowledge, skills, and competencies that are sufficient to accomplish key work outcomes
Fletcher	Competency refers to some kind of behavior, which is concrete, observable, verifiable and can be classified logically

levels, making a comprehensive summary of human knowledge, skills, social roles, self-concept, personality, and motivation, and forming a complete quality model for enterprise employees. Figure 1.

There are three generally accepted competency models, namely, iceberg model, onion model and trapezoidal model. Figure 2. The details of these three general models are as follows. Figure 3.

- (1) Iceberg model is proposed by Spencer competency iceberg model. As shown in Figure 1, the model divides competency into two parts. Specifically, the first part is the iceberg above the level of the revealed part, including knowledge and skills of two competency characteristics elements that are explicit competency characteristics elements. The second part is the iceberg hidden level below the part, including social roles, self-image, personal characteristics, and motivation, which are inherent, recessive, competency elements.
- (2) Onion model is proposed by Boyatzis competency onion model. As shown in Figure 2, the principle of competency iceberg model is basically similar, and competency onion model from inside to outside illustrates that the various elements of competency can be gradually observed, measured characteristics. In the onion model, the explicit competency elements are placed at the outermost layer of the onion model, and the potential, hidden, and internal competency elements are placed inside the onion model. Thus, a layer-by-layer competency onion model is constructed from inside to outside. From the outside to the inside, the difficulty of observability, cultivation, and evaluation of competency elements gradually increases. The outermost

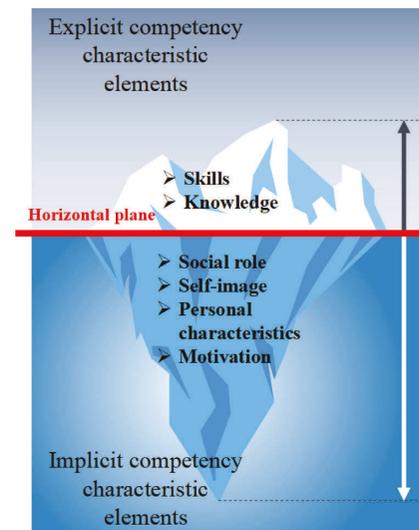


FIGURE 1: Iceberg model of competence.

competency elements are relatively easy to be observed and evaluated, and they are also most likely to be cultivated. However, the more the inner layer is, the more it can reflect the future work performance. Motivation and personal characteristics at the core layer are the most reliable and stable competency.

- (3) The trapezoidal model is proposed by the International Institute of Human Resources Management. As shown in Figure 3, the competency ladder model is divided into six levels from top to bottom, namely knowledge, skills, social roles, self-concept, personal traits, and motivations. Among them, self-concept

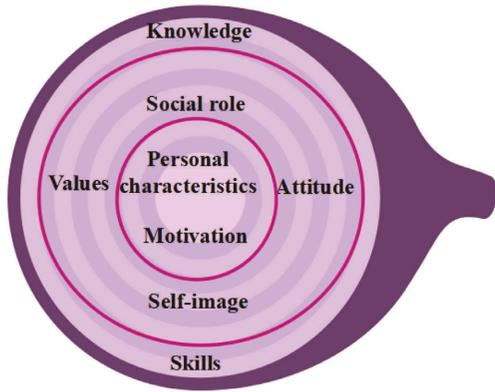


FIGURE 2: Competency model of the onion.

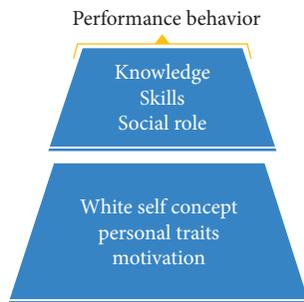


FIGURE 3: Competency trapezoidal model.

refers to the perception and understanding of individual identity. Specifically, the top of the ladder is personal performance behavior, and the six levels at the bottom of the ladder affect the reflection of individual's job objectives to varying degrees, thus determining the top of the ladder's personal performance behavior.

With the rapid development of new computer technology, a series of new methods have emerged for competency model building.

### 3. Problems in HRM Positions

*3.1. Analysis of Current Situation of Personnel in HRM.* The work done by human resources management personnel is closely related to performance. If the management personnel want to complete the post work with high quality and efficiency, they must have the quality consistent with the post. HRM post personnel can successfully complete the work and reflect that the core quality of work value is the post competency model, including ability, characteristics, knowledge, skills, self-awareness, and values. At present, human resources management posts present the following phenomena:

- (1) **Multidimensionality:** the competency of HRM posts includes various forms of quality, including both representational quality (knowledge, skills, etc.) and psychological quality (ability, characteristics, etc.).

Multidimensional quality together constitutes the competency model of management posts.

- (2) **Dynamic:** the environment of HRM position is constantly changing, including external macro environment, internal enterprise environment, and industry environment, which also causes the change of position environment and elements. In order to meet job requirements, job competency must be adjusted with the change of environment.
- (3) **Specificity:** HRM post competency model will be affected by post environment, incentive mechanism, constraint mechanism, job responsibilities, and so on. It is closely related to specific jobs. The quality requirements of different jobs are also different, and different specific competency models are also different.
- (4) **Strategic:** HRM post model includes a variety of core qualities, which can promote the efficient work of employees and help enterprises to achieve strategic objectives.
- (5) **Level:** in the internal structure of human resources management posts, different grades have different levels, and the requirements are not the same, that is, each grade must have an independent post quality, that is, the post quality model is the comprehensive competency model of different grades of posts, and the level of post competency model is directly related to the level of grades.

*3.2. Problems of HRM Personnel.* In the process of enterprise development, the reasonable application of competency model, from the perspective of enterprise performance management to carry out dynamic management and service, ensure that the enterprise internal different business transactions and different business can achieve reasonable docking. But the current development has the following problems.

- (1) The recruitment and selection of human resources management posts are backward. Enterprises are accustomed to the old system and norms. The selection and selection methods of talents in their management positions are relatively backward, and the selection criteria of talents are relatively simple. They pay attention to high academic qualifications, high professional titles, and rich working experience, but they are easy to ignore the specialty and potential of candidates. Many enterprises are accustomed to hiring familiar employees, and there are still related households in terms of promotion, which to some extent hinders the efficiency of human resources utilization in enterprises, and also affects the optimal utilization and composition of human resources within the organization.
- (2) The performance management mechanism of human resources management posts needs to be improved. Although many enterprises have established

a simple performance management system, some performance management mechanisms are mere formality and do not really play their effectiveness. The main performance is not well-applied performance management system, and assessment implementation process is not standardized. In the process of performance evaluation, due to the large number of enterprises and complex relations, performance management often considers acquaintance relations, which brings some emotional colors to the implementation of performance evaluation and affects the fairness and rationality of HRM in the whole enterprise.

- (3) The design of HRM training system needs to be improved. Enterprise internal training mode is mostly endogenous growth, training effect needs to be improved, and training system design needs to be improved. From all aspects such as entry and promotion, new recruits need prejob training to be employed. But in this process, there are also fewer participants training, training management is not standardized, many ginseng training frequency and frequency is low, training learning is not strict enough, training management is a mere formality, and it is difficult to achieve the training effect required by the enterprise.
- (4) The personal development plan design of HRM post is not clear enough. Employees are social elites with high education and professional title and good interpersonal relationship. They have urgent needs for the future, but their career planning is not clear enough to meet the current situation. In state-owned enterprises, the phenomenon of seniors in the field of investment is relatively serious. Many old employees are used to passive arrangement of their own career paths and lack active planning. In addition, the Ministry of Human Resources Management of the staff professional channels lack of scientific and reasonable settings, business staff career channels single, many people have little hope for promotion, to a certain extent, affected the enthusiasm of professional and technical personnel.
- (5) Talent inventory in human resources management positions is a mere formality. Traditional enterprises prone to error talent inventory purposes: in the process of business transformation to feel the pain of talent management to carry out talent inventory, and not the talent inventory as a routine management process. In addition, companies mistakenly think that the inventory result is to promote people, rather than more scientific classification of team personnel management, improve team effectiveness. Some enterprises' talent inventory is formalistic, with talent inventory every year, but no further follow-up and application of inventory results.
- (6) Human resources planning needs to be improved. Some enterprises believe that the planning of HRM is

not related to the strategic development and business objectives, so there is no idea of combining HRM with business objectives. The lack of reasonable planning and connection between human resource planning and enterprise management directly affects the sustainable development of enterprises. In the implementation process of human resource planning, some enterprises simply use past historical data as support to predict the current human resource data for the convenience of work. This measure is difficult to provide accurate human resource planning data for enterprises and cannot provide strong support for the talent training of enterprises.

*3.3. Necessity of Building Manager Competency Model Based on Machine Learning.* In order to ensure the sustainable development of enterprises and attract more excellent human resources, enterprises should build performance-based human resource management competency model to ensure that the talent market and the competitive market environment can achieve good coordination and matching, to ensure that the two can be fully integrated. It is believed that the application value of competency model in the field of HRM positions is huge, especially in recruitment, training, and employee development. The status of competency model system in the field of human resources management can be shown in Figure 4.

Step 1. As shown in the line 1 in Figure 4, when the strategy of the enterprise changes, the roles and responsibilities of various departments and employees have also changed accordingly, and the individual competency requirements of the enterprise will also be different from the past. At this time, the original competency model has been unable to accurately reflect the new enterprise development strategy needs of the staff ability and quality requirements. Therefore, enterprises need to re-adjust the competency model according to the new strategic objectives and business priorities.

Step 2. As shown in Route 2 in Figure 4, when the enterprise revises the original competency model according to the new strategic objectives in a timely manner, that is, after redefined the competencies and qualities necessary for the staff, it is not possible to evaluate the performance of the staff in accordance with the previous evaluation methods, but to evaluate the performance of the staff in daily work according to the competency elements defined in the new competency model, and there will be some competency assessment results.

Step 3. As shown in Route 3 in Figure 4, the existing competency level of the staff obtained through scientific evaluation in the second step is compared and analyzed with the competency level necessary to achieve the position, and the gap is concluded. In view of the existing gap, to design to improve staff competency

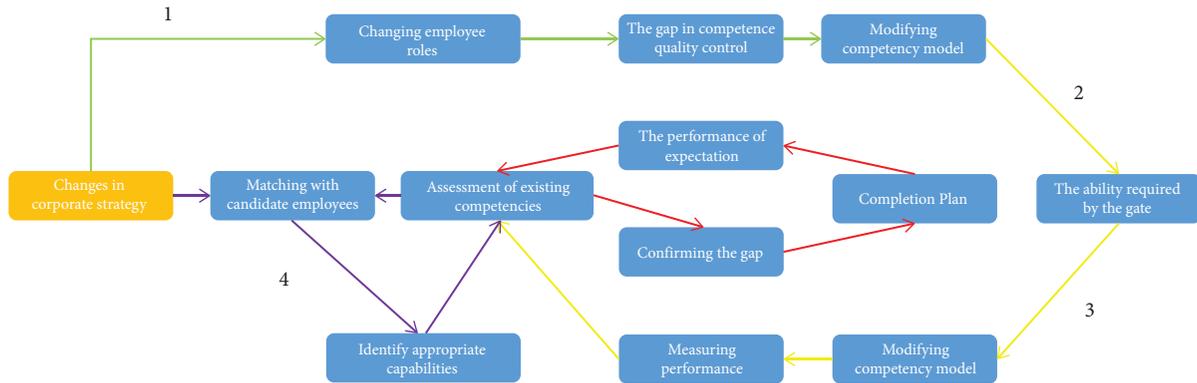


FIGURE 4: Competency model and HRM system.

plan, and targeted to develop the corresponding training plan.

Step 4. As shown in Figure 4 in line 4, if the second step is over, the existing competency level has reached the standard of the position and even reached the requirements of the upper level; or appropriate training makes the staff’s competency has been improved, to meet the requirements of the position or the superior position, then the enterprise will be the existing staff competency level and competency model matching, as a basis, to determine whether the staff is to remain or promote the superior position.

The cycle of the above four steps, in which the work content and competency model are adjusted and adapted to the changes of corporate strategic objectives to ensure that HRM strategies and business activities are always consistent with strategic objectives. But in practical application, various factors are changing rapidly, making the competency model complicated. However, the combination of machine learning method in the competency model of HRM posts will greatly reduce the establishment time and result analysis of competency model.

#### 4. Construction of Human Resource Competency Model Based on BP Neural Network

Through literature review, semi-structured interviews and open questionnaire survey, the competency modulus table of HRM positions in Company C is obtained, which provides basic data for the subsequent establishment of human resource competency model based on machine learning assistance [21–23]. Company C management post competency model design process is shown in Figure 5.

4.1. Literature Review. Through questionnaires, on-site interviews, literature review analysis, and other methods to obtain information on the competency and job performance of middle-level managers in enterprises, the theme of the survey interview is determined to be “list the key competencies you think you need to do a good job in middle-level management.” Interviews with middle-level managers

around the theme to obtain the ability characteristics that excellent middle-level managers should have. Five dimensions and 22 related competency elements are summarized. The index system of the general competency characteristics of management talents in Company C is shown in Figure 6.

4.2. Semistructured Interviews. A semi-open interview is conducted on the management staff of Company C, which mainly adopts one-to-one semi-structured interview. The semi-structured interview system is shown in Figure 7.

4.3. Open Form Questionnaire. The characteristics of the questionnaire in this paper are that participants can freely express their views and opinions according to their own experience and ideas and the way participants fill in the questionnaire is to answer freely. The structure chart of questionnaire competency index system is shown in Figure 8.

4.4. Company C Management Post Competency Index. The basic components of the enterprise competency model (knowledge, skills, social roles, etc.) were determined through a literature review. Semi-structured interviews refer to informal discussions conducted with a rough outline to obtain components of the enterprise competency model (values, attitudes, motivations, etc.). The open questionnaire survey gets the index size of each factor index among employees [24–26]. In this paper, the final determination of C Company management post competency model is shown in Figure 9.

A total of 110 samples of human resources management positions in Company C in 2021 are collected in Table 2. 110 samples can be divided into excellent performance and other performance samples, of which 64 are excellent performance samples and 46 are other samples.

#### 5. Construction of Human Resource Competency Model Based on GA-BP Neural Network

5.1. Genetic Algorithm Model. Genetic algorithm is an evolutionary algorithm. Its basic idea is based on Darwim’s

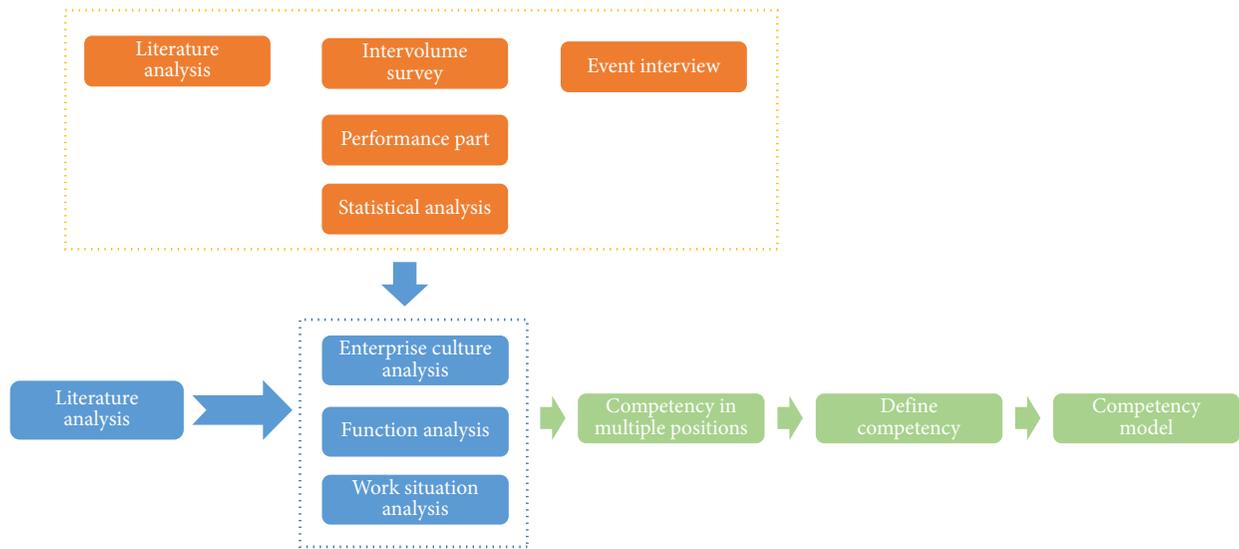


FIGURE 5: Competency model construction process of Company C.

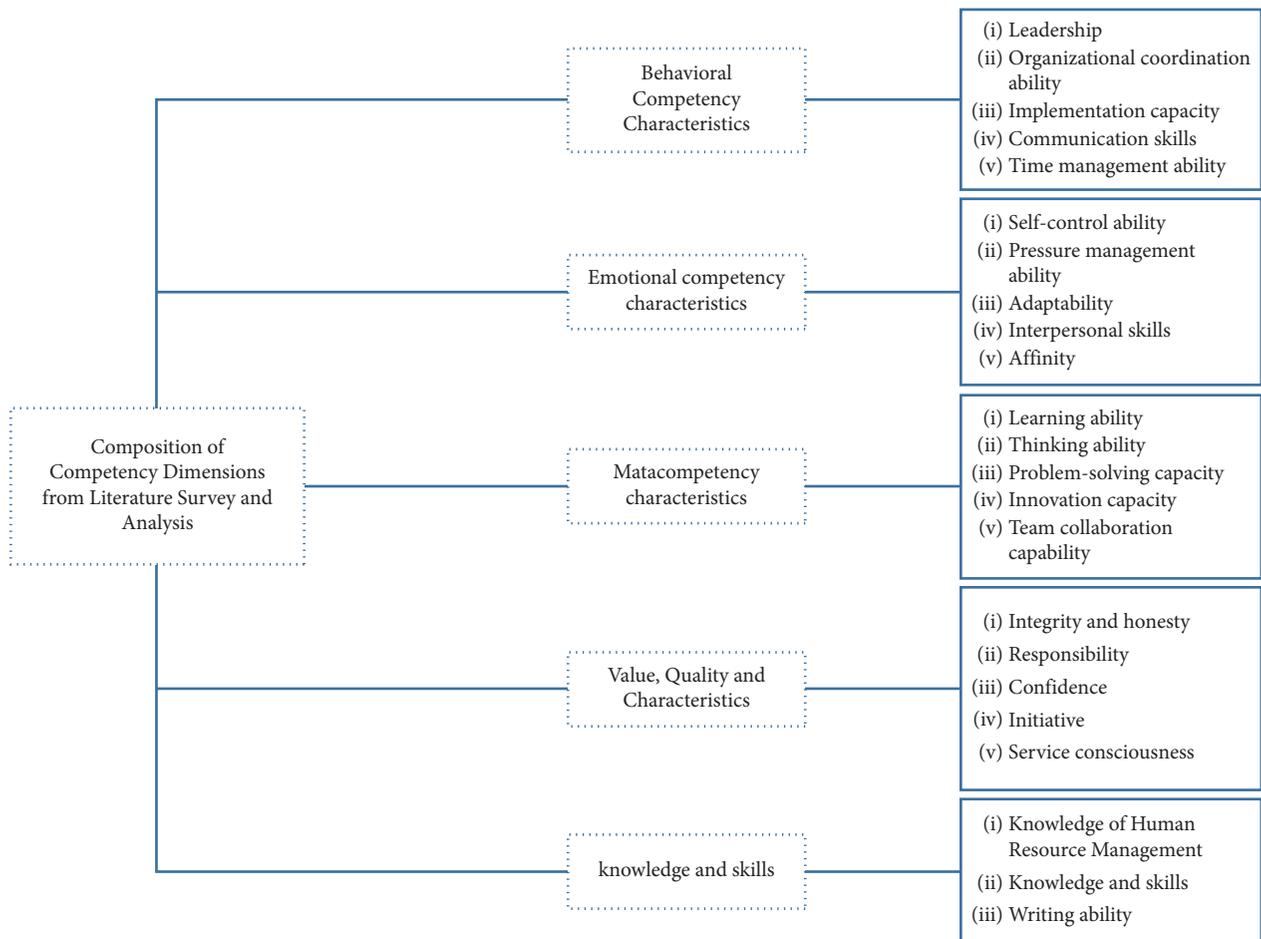


FIGURE 6: Competency index system from literature.

theory of evolution and Mendel’s theory of genetics. It was first proposed by Professor J. Holland of Michigan University in 1962. It is a parallel random global optimization search algorithm based on natural genetic law and biological

evolution. The algorithm is evolved from the genetic mechanism of natural competition and survival of the fittest. Through the combination of mathematical principles and computer simulation, a series of selection, crossover, and

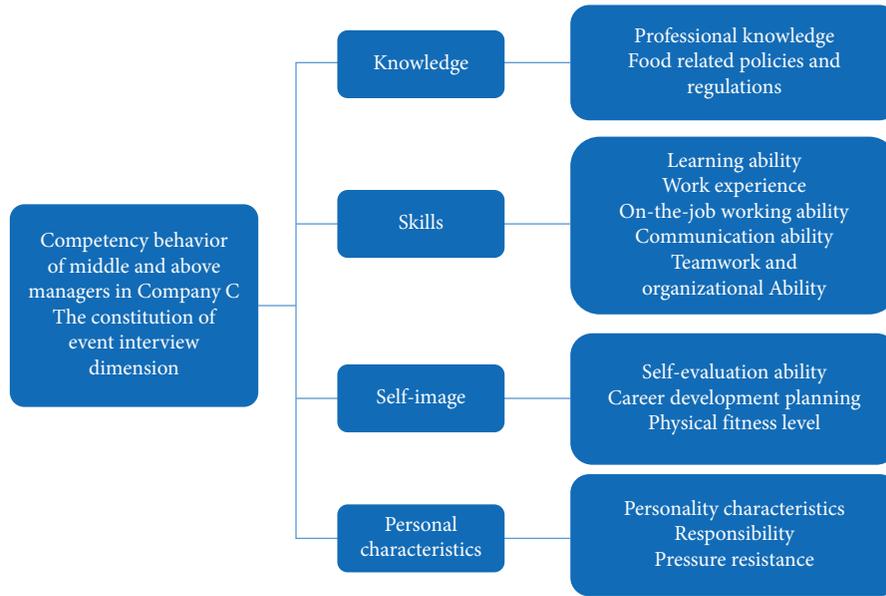


FIGURE 7: Semi-structured interview competency index system structure.

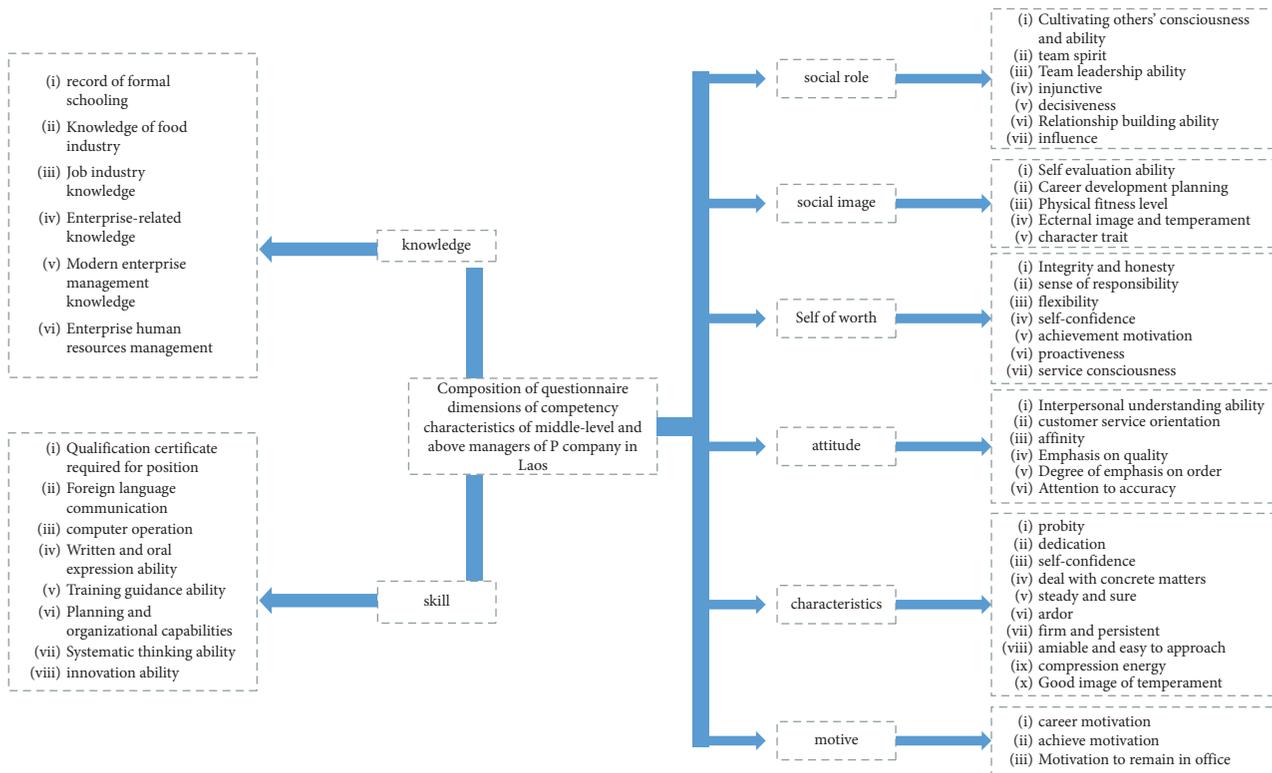


FIGURE 8: Questionnaire competency index system.

mutation operations are carried out on biological chromosome genes to imitate the biological evolution in nature, so as to obtain the best offspring, namely the optimal solution. Genetic algorithm has good global search ability.

Compared with the traditional gradient descent algorithm, it is easy to fall into local optimal solution, and genetic algorithm has certain advantages. This method has the characteristics of efficient heuristic search and parallel

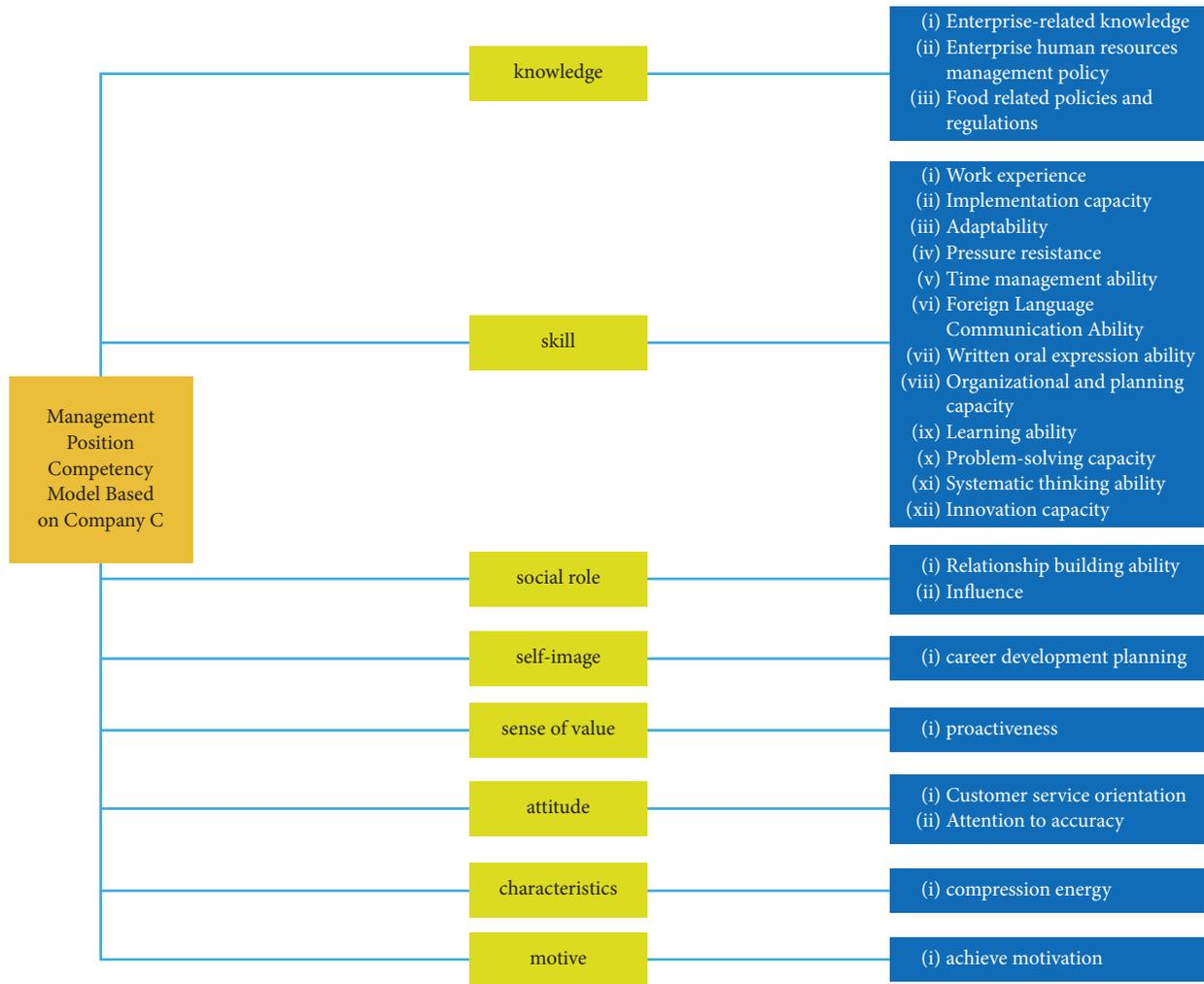


FIGURE 9: Company C management post competency model.

TABLE 2: Data set.

Sample number	Excellent performance samples	Other performance samples
110	64	46

computing and is usually used in functional optimization, combinatorial optimization. and production planning [27–30].

The main process of genetic algorithm is as follows:.

Step 1. Coding: coding the solution of the problem in the form suitable for genetic algorithm is called the representation of genetic algorithm, and the coding methods include binary coding, real number coding, integer coding, and tree coding.

Step 2. Generate the initial population, that is, select several of the solutions to form the initial population, which is generally generated by random method.

Step 3. Fitness evaluation: introduce fitness to evaluate the ability of each individual in the selected initial population to adapt to the surrounding environment. The specific method is to calculate the fitness value of each individual through the fitness function to compare the differences between individuals, mainly with or without constraints and constraints of two fitness functions.

Step 4. Selection: selection is to extract the individual with higher fitness value as the parent and enter the next stage of cross operation. The commonly used method is the roulette method. Since the probability of each individual being selected is proportional to the fitness value, the basic principle is to select according to the proportion of individual fitness value.

Step 5. Crossing: part of the genes in the coding chain of two parent individuals are exchanged to produce a new individual. Cross operation is the main means to generate new individuals. For real number coding, the cross method includes discrete recombination, linear

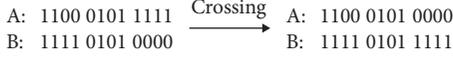


FIGURE 10: Crossover process.

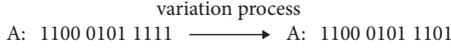


FIGURE 11: Variation process.

recombination, and intermediate recombination. Cross operation is shown in Figure 10.

Step 6. Variation: mutation is to change the values of some loci of individuals randomly selected in the initial population with a certain probability (usually called mutation probability). The mutation operation is shown in Figure 11.

Step 7. Termination condition judgment: The optimal solution is obtained by the termination algorithm.

**5.2. BP Neural Network.** BP neural network is a neural network with three or more layers. Any network is composed of an input layer, an output layer, and one or more hidden layers in the middle layer. Each layer contains several neurons responsible for information processing. There is no connection between the neurons in the same layer, and the adjacent two neurons are fully connected by weights. However, each neuron only accepts the input of the previous layer and is responsible for exporting the information to the next layer without feedback to itself. The hidden layer can be one or more layers between the input layer and the output layer. The function of the internal representation of the hidden layer as the input mode is to extract the features contained in a class of input modes that are different from those contained in other types of input modes and to transfer them to the output layer. Due to the unique recognition function of the hidden layer, it is also called the feature extraction layer. The process of feature extraction in hidden layer is the process of self-organizing the weights between the input layer and the hidden layer. That is, the weights between the input layer, the hidden layer, and the output layer are gradually adjusted from the initial random value during the training process of the network, and finally the learning process that can characterize the characteristics of the input mode is achieved. The common three-layer neural network topology is shown in Figure 12.

The network of three layers, shown in Figure 12, consists of the input layer, the hidden layer, and the output layer. Full connection between the upper and lower layers and no connection between each layer of neurons. When a pair of learning samples are provided to the network, the activation value of neurons propagates from the input layer through the hidden layer to the output layer, and each neuron in the output layer obtains the input response of the network.

Data preprocessing is to convert various data and nondata into positive data indicators. Depending on the nature of the indicators, different conversion methods were

used. For example, the data obtained by the competency model scale usually belongs to quantitative data such as the lowest score of 0 points, the highest score of 5 points. The data obtained after pretreatment should be the dimension matrix  $n \times m$ , where  $n$  is the number of samples, that is, the number of respondents;  $m$  is the number of evaluation index factors, namely the input of artificial neural network.

In the forward propagation mode, through the input vector  $A_k = (a_1, a_2, \dots, a_m)$ , where  $k = 1, 2, \dots, n$  is the serial number  $m$  of the training sample, which is the number of neurons in the input layer. The input of the input layer is the evaluation result of each competency index. The function of the input unit is to accept the external input mode and transmit it to all the units of the hidden layer connected to it.

Calculate the hidden layer input  $S_k = (S_1, S_2, \dots, S_p)$ , where  $p$  is the number of hidden layer neurons. The input value of the hidden layer is the function of the difference between the input weighted sum and the threshold:

$$s_j = \sum_{i=1}^m w_{ij} a_i - \theta_j \quad (1)$$

where  $a_i$  is the output value,  $w_{ij}$  is the link weight between the input layer and the hidden layer,  $i = 1, 2, \dots, m$  is the serial number of the input unit,  $j = 1, 2, \dots, p$  is the serial number of the hidden layer unit, and  $\theta_j$  is the threshold of the hidden layer neurons.

Calculate the hidden layer output  $B_k = (B_1, B_2, \dots, B_p)$ . The function of the hidden layer unit is to generate a set of output values by the over-type nonlinear function after weighted summation of all the input values and then transmit them to all the units connected to the output layer. The output value of the layer is S (Sigmoid) function.

$$b_j = f(s_j) = \frac{1}{1 + e^{-s_j}} \quad (2)$$

Calculate the number of output layer input  $L_k = (l_1, l_2, \dots, l_q)$ ,  $q$  is the number of output layer neurons. The output layer input value is a function of the difference between the hidden layer output weighted sum and the threshold.

$$l_k = \sum_{j=1}^p v_{jt} b_j - r_t \quad (3)$$

where  $v_{jt}$  is the link weight between the hidden layer and the input layer,  $q$  is the serial number of the output unit, and  $r_t$  is the threshold of the output layer neurons. In calculating the output layer output  $C_k = (c_1, c_2, \dots, c_q)$ .

$$c_k = f(l_t) = \frac{1}{1 + e^{-l_t}} \quad (4)$$

The inverse propagation mode is carried out, and the output vector  $Y_k = (y_1, y_2, \dots, y_q)$  is preset to calculate the correction error of the output layer.

$$d_t = (y_t - c_t) \cdot c_t (1 - c_t), \quad (5)$$

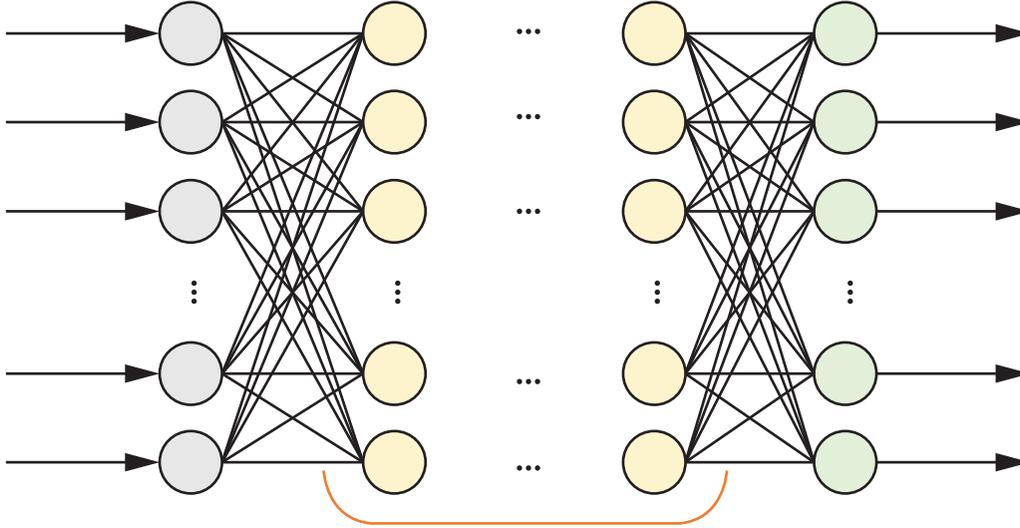


FIGURE 12: Three-layer BP network structure.

where  $d_t$  is the output value of the network, that is, the actual output of the  $t$  neuron,  $(y_t - c_t)$  represents the absolute error between the expected output and the actual output.  $c_t(1 - c_t)$  is the first-order differential of the output layer  $S$  function, which indicates that the deviation is adjusted according to the actual response of each element.

The connection weight correction between the output layer and the hidden cross is calculated as

$$v_{jt}(N+1) = v_{jt}(N) + a \cdot d_t \cdot b_j, \quad (6)$$

where  $a$  is the learning factor. The threshold correction between the output layer and the hidden layer is calculated as

$$r_t(N+1) = r_t(N) + a \cdot d_t. \quad (7)$$

The correction error of the hidden layer is calculated.

$$e_j = \left( \sum_{t=1}^q d_t \cdot v_{ij} \right) b_j (1 - b_j), \quad (8)$$

where  $b_j(1 - b_j)$  is the first-order differential of the hidden layer  $S$  function. The meaning of  $e_j$  is like  $d_t$ . The correction error of each hidden layer is generated by the correction of  $q$  output units. Connection weights between the hidden layer and the output layer are calculated.

$$w_{it}(N+1) = w_{it}(N) + \beta \cdot e_j \cdot a_i, \quad (9)$$

where  $\beta$  is the momentum factor. Then calculate the threshold correction between the hidden layer and the input layer.

$$\theta_j(N+1) = \theta_j(N) + \beta \cdot e_j. \quad (10)$$

Calculate the  $k^{\text{th}}$  sample error.

$$E_k = \frac{1}{2} \sum_{t=1}^q (y_t - c_t)^2 \quad (11)$$

Calculate the average error of all test samples.

$$E = \frac{1}{n} \sum_{k=1}^n E_k. \quad (12)$$

After repeated iterations, when the error is less than the allowable value, the network training process is ended.

### 5.3. Genetic Algorithm Optimization Bp Neural Network.

BP neural network is an algorithm based on the principle of gradient descent. The selection of initial weights and thresholds is random and lacks scientific basis, resulting in BP neural network is more likely to fall into local optimal solution and the global search ability is relatively poor, and the final prediction accuracy is affected. To solve this problem, genetic algorithm for distributed information exploration and collection can cover the whole space, with the characteristics of global search. Therefore, this paper will use genetic algorithm to optimize the original BP neural network. Aiming at the problem that the initial weights and thresholds of BP neural network are randomly generated, genetic algorithm is used to optimize the initial weights and thresholds. Combining the characteristics of the two, the GA-BP neural network is constructed to make up for the defects of the random initial weights and thresholds of the BP neural network. The GA-BP neural network has the advantages of the nonlinear mapping of the BP neural network and the global search of the genetic algorithm, which further improves the prediction accuracy of the BP network, and finally obtains the global optimal solution as shown in Figure 13.

### 5.4. Establishment of Human Resource Competency Model Based on GA-BP Neural Network.

The process of genetic algorithm optimization mainly includes the determination of network basic topology, genetic algorithm optimization, and neural network prediction. First, the BP neural network topology is optimized by genetic algorithm, which mainly

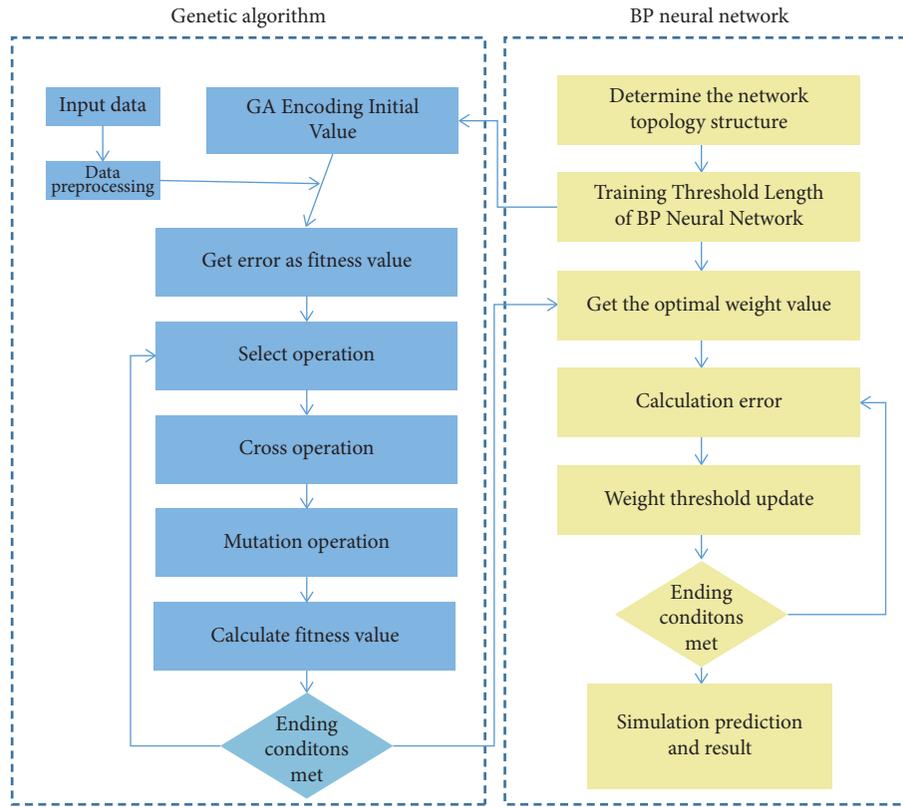


FIGURE 13: GA-BP neural network flow chart.

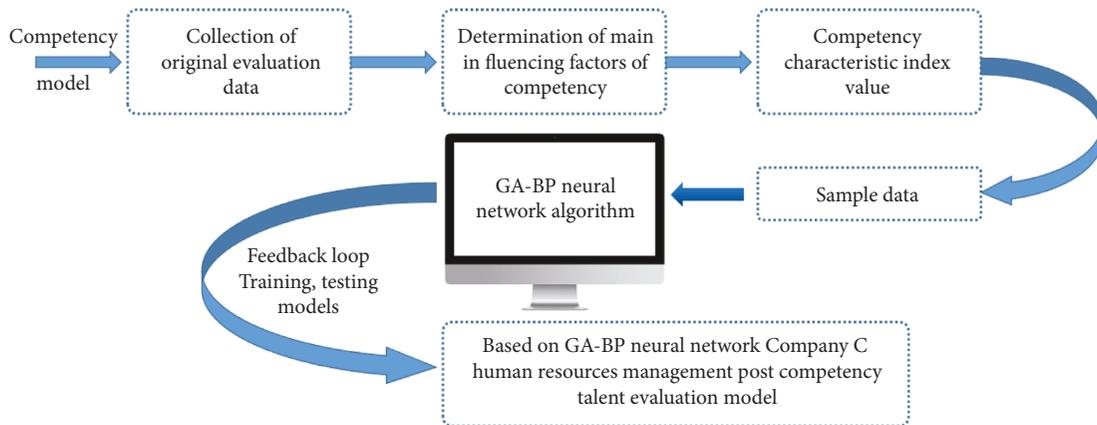


FIGURE 14: Based on GA-BP neural network Company C human resources management post competency model.

TABLE 3: Number of competency characteristic elements.

Source of characteristic elements	Total source	Number selected
Literature analysis	20	6
Questionnaire survey	50	10
Semi-structured interview	10	4
Total	80	20

includes the real number coding of the initial weights and thresholds of the network to obtain the initial population, and the fitness value of each individual is calculated by the fitness function. On this basis, the selection, crossover, and mutation operations are carried out. Finally, the

corresponding individuals of the optimal fitness value, namely the new network weights and thresholds, are found in the continuous iterative evolution process. At this time, the optimized network starts to learn the training process and finally predicts the output value of the function. Establishment of human resource competency model based on BP optimized by genetic algorithm is shown in Figure 14.

There are 6 characteristic elements from literature analysis, 10 characteristic elements from questionnaire survey, and 5 characteristic elements from behavioral event interview. The total number of selected characteristic elements is 20 and is shown in Table 3.

TABLE 4: Division of training set and test set.

Data set	Sample number	Excellent performance	Other performance
Training sets	90	53	37
Testing set	20	13	7

TABLE 5: Confusion matrix of GA-BP neural network model.

Model		Excellent performance	Other performance	Prediction
GA-BP	Excellent performance	92.31	7.69	91.16
	Other performance	10.00	90.00	

The sample data set is divided into training set and test set, in which the proportion of training set is 80%, and the proportion of test set is 20%. The same principle is shown in Table 4.

The GA-BP neural network model is applied to the human resources management position of Company C. As shown in Table 5, it is found that the prediction accuracy of the model is very high, and the prediction accuracy reaches 91.16%. The competency model of HRM based on machine learning can scientifically, objectively, effectively, and quickly identify the employees with excellent performance from the candidate employees and can also effectively identify whether the employees have the potential to some extent.

## 6. Conclusion

With the rapid development of modern enterprises, middle managers, as the connecting hub between the grass roots and senior levels of enterprises, have been paid more and more attention to their competence and job performance. The research on the relationship between competency and job performance has attracted more and more attention. Managers' competency is not immutable. Different times and different business environments have great differences in the requirements of enterprise managers' ability. The actual environment has different requirements for managers' competency. As managers, they must dynamically adjust to meet the actual needs in order to remain invincible in the fierce competition.

This paper mainly studies the establishment of HRM post competency model based on machine learning and uses the GA-BP algorithm in machine learning to construct the HRM post competency model of Company C. The empirical research on the internal relationship between managers' competence and job performance shows that if job performance is different, their competence characteristics must be different. In this paper, 110 employees of management positions in Company C are completed and divided into experimental data sets by questionnaire survey and semi-structured interview. Taking the construction of management position competency model of Company C as the goal, the GA-BP neural network classification algorithm is used to construct the competency model of HRM positions based on GA-BP neural network. From the evaluation results, the HRM post competency method based on machine learning

can minimize the impact of human factors and avoid the uncertainty of traditional methods. The quantitative analysis of GA-BP neural network model has obtained 91.16% classification accuracy, which verifies the application prospect of machine learning in the construction of auxiliary competency model.

## Data Availability

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

## Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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