Research on a New Performance Evaluation Method for University Research Project Management

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Abstract. The performance evaluation of university research project management plays a crucial role in enhancing project management and promoting scientific research development. This study proposes an improved approach to enhance the accuracy of the BP neural network algorithm in project management performance evaluation by combining it with genetic algorithm. The proposed method incorporates genetic algorithm into the BP neural network to search for optimal initial network weights and thresholds, obtaining the optimal solution through training. To verify the feasibility of this method, we conducted a performance evaluation of the research project management at Chengyi College of Jimei University. The experimental results demonstrate that this method exhibits strong non-linear fitting capability and higher evaluation accuracy, making it suitable for evaluating the performance of university research project management. This research achievement provides an effective tool for enhancing the performance evaluation of university research project management, improving project management practices, and offering scientific and reliable decision-making basis for university management.

Keywords: University research projects; Genetic algorithm; Digital management; Neural networks

1 Introduction

The performance evaluation of university research project management is crucial for enhancing management level and promoting scientific research development. It facilitates the efficient utilization of resources, evaluates cost-effectiveness, and provides a comprehensive and objective assessment of research outcomes. Furthermore, it motivates researchers to conduct innovative and impactful studies, driving academic progress and technological innovation. Additionally, performance evaluation serves as a feedback mechanism for university research project management, improving efficiency and effectiveness through process improvement and optimization. [1][2]

Applying BP neural networks to the performance evaluation of university research project management has several advantages. First and foremost, BP neural networks possess robust data modeling capabilities. They can be trained and learn from a vast amount of historical data, enabling the establishment of accurate prediction models. In the context of research project management, BP neural networks can analyze and extract various data during project execution, such as resource input, progress, and outcomes, aiding in the evaluation of project performance. Secondly, BP neural networks have strong capabilities in modeling non-linear relationships.

MSIEID 2023, December 08-10, Guangzhou, People's Republic of China

DOI 10.4108/eai.8-12-2023.2344752

Performance evaluation in research project management involves complex non-linear relationships that traditional linear models struggle to accurately capture. However, BP neural networks, being capable of non-linear mapping, can better handle non-linear problems and adapt more effectively to the complex performance evaluation issues in research project management. Furthermore, BP neural networks exhibit adaptability. Through iterative learning and adjustment of weights and biases, they possess the ability to adapt to changing model parameters based on new input data. This adaptability is particularly valuable in research project management, where performance evaluation indicators may change over time due to varying project characteristics and environmental factors. BP neural networks also demonstrate multivariate analysis capabilities, which are essential for evaluating the interrelationships among multiple relevant variables in research project performance evaluation. By simultaneously considering multiple input variables and establishing complex relationships among them through adjustments in weights and biases, BP neural networks provide a more comprehensive assessment of project performance. Lastly, BP neural networks offer high accuracy in predictions. By training on historical data and leveraging learned patterns and rules, they can make precise predictions. Applying BP neural networks to the performance evaluation of university research project management allows for utilizing existing data to forecast future performance accurately. This high accuracy in prediction aids research project decision-makers in making informed decisions during implementation, consequently improving project management efficiency and effectiveness. [3][4]

The combination of genetic algorithms and BP neural networks in the performance evaluation of university research project management has several advantages, addressing some of the limitations of using BP neural networks alone. This research adopts a predictive model that incorporates genetic algorithms and BP neural networks to enhance performance evaluation. The model offers the following advantages: Firstly, genetic algorithms possess global search capabilities by simulating the process of biological evolution for global optimization. By combining genetic algorithms with BP neural networks, the full potential of genetic algorithms' global search abilities can be utilized to find more optimized combinations of performance evaluation indicators. Secondly, genetic algorithms can optimize the parameter settings of the BP neural network, improving the performance and accuracy of the model. Since the performance of the BP neural network is highly influenced by parameter selection, utilizing genetic algorithms for parameter optimization can enhance the model's performance. Additionally, genetic algorithms have data feature extraction capabilities, which can be used to select and extract the most representative features, thereby improving the learning effect of the model and reducing the dimensionality of the input data. Furthermore, the combination of genetic algorithms and BP neural networks enables multi-objective optimization, finding the best trade-off solution by considering the relationships between various indicators comprehensively. Lastly, this predictive model exhibits real-time learning and adaptability, allowing for dynamic adjustments based on changes in the research project management environment and conditions. This ensures the accuracy and reliability of the model, meeting practical requirements. [5][6]

2 Algorithm design

2.1 Basic Principles

The Genetic Algorithm (GA) is an optimization algorithm that simulates the natural evolution process, combining ideas from evolutionary theory and genetics. The Backpropagation (BP) neural network is a commonly used machine learning algorithm for solving classification, regression, and other problems.

The basic principle of improving the BP neural network with genetic algorithms is to enhance the performance of the neural network by combining the optimization ability of genetic algorithms with the learning ability of BP neural networks. Firstly, initialize a population consisting of multiple individuals, where each individual represents the weights and biases of the BP neural network. Then, evaluate the performance of each individual in the training set based on their fitness. Next, use selection operations to choose better individuals from the population as parents, and perform crossover and mutation operations to generate new offspring individuals. Repeat the selection, crossover, and mutation operations to create a new population. Finally, determine whether to terminate the execution of the genetic algorithm based on predefined termination conditions, and output the optimal individual as the optimal solution for the BP neural network. Through this iterative process, genetic algorithms can optimize the initial weights and biases of the BP neural network, improving its performance and convergence speed, and enhancing its generalization ability.

2.2 Implementation steps of the algorithm

The basic steps of using genetic algorithm to improve BP neural network are as follows:[7]

1. Initialize population: create an initial population composed of multiple individuals, and each individual represents the weight and offset of a BP neural network.

2. Fitness evaluation: for each individual, train the BP neural network and calculate its fitness on the training set. The fitness is determined according to the size of the error (mean square error).

3. Selection operation: select some excellent individuals from the population as the parents by using the selection operation according to the individual fitness value. This study uses roulette wheel selection. If the population size is N and the fitness of individual xi is f (x_i), the selection probability of individual x_i is equation (1).

$$P(x_i) = \frac{f(x_i)}{\sum_{j=1}^{N} f(x_j)} \quad (1)$$

The roulette wheel selection method is realized by the following process simulation:[8]

(1) Generate a uniformly distributed random number r in [0,1].

(2) If $r \leq q_1$, chromosome x_1 is selected.

(3) If $q_{k-1} < r \leq q_k$ ($2 \leq k \leq N$), chromosome x_k is selected.

Where q_i is called the accumulation probability of chromosome x_i (i=1, 2,..., n), and its calculation formula is equation (2).

$$q_i = \sum_{j=1}^{i} P(x_j) \quad (2)$$

4. Crossover operation: Select two parent individuals and generate a new offspring individual by exchanging their gene information (i.e. weights and biases). Crossover operation can be done using single-point crossover, multi-point crossover, or uniform crossover.

5. Mutation operation: Randomly mutate the gene information of the offspring individual. Mutation operation can be single-point mutation, multi-point mutation, or uniform mutation. Mutation operation helps introduce new genes and increase the diversity of the population.

6. Update population: Generate a new population through repeated selection, crossover, and mutation operations.

7. Termination condition: Based on the preset termination condition (reaching the maximum number of iterations or the error being below a preset threshold), determine whether to terminate the execution of the genetic algorithm. If the termination condition is met, output the optimal individual as the optimal solution for the BP neural network.

8. Update BP neural network: Apply the gene information of the optimal individual to the BP neural network and update its weights and biases.

9. Repeat steps 2 to 8: Repeat the above steps until the termination condition is met.

Through these steps, the genetic algorithm can continuously optimize the weights and biases of the BP neural network, improve its performance and convergence speed, and achieve better training results.

2.3 Algorithm Flow

As shown in Figure 1, the algorithm flow includes two main parts: BP neural network and genetic algorithm.

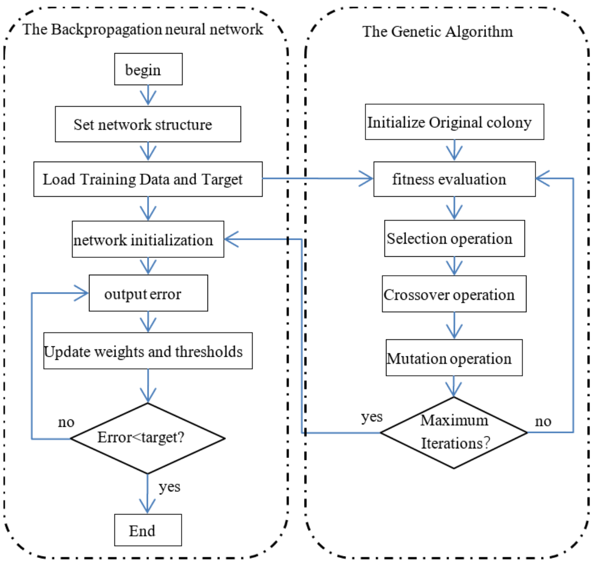

Fig. 1. Genetic algorithm improved BP neural network flowchart

3 Experiment and analysis

This chapter focuses on the empirical analysis of performance evaluation for university research project management, using the specific case of Chengyi College at Jimei University as an example.

3.1 Data source and pretreatment

The data for this study is collected from the compilation of research projects at different levels in Chengyi College, Jimei University, from 2015 to 2022. A total of 585 research projects were collected (as shown in Table 1, only a partial display due to the large number). Among them, there were 34 projects in 2015, 64 projects in 2016, 81 projects in 2017, 59 projects in 2018, 91 projects in 2019, 74 projects in 2020, 108 projects in 2021, and 74 projects in 2022.

Table 1. Summary of research projects at all levels from 2015 to 2022

No.	Project Title	Funding (in ten thousand RMB)		Duration (in months)		Achievement		Connotation Score
		Funding Allocation	Actual Completion	Planned Duration	Actual Duration	Rank	Impact Factor	
1	Research on Occupational Psychological Maintenance and Enhancement of University Counselors	1.86	1.53	36	30	60	3.33	260
2	Research on the Impact of Technological Content Deepening in Fujian Free Trade Zone Export Trade	1.71	1.7	36	25	60	1.76	260
3	Research on Budget Elaboration of Local Government and Rule of Law Anti-Corruption	1.56	1.4	36	33	60	1.76	260
4	Research on Current Status, Influencing Factors, and Upgrading Strategies of Export Product Structure in Fujian Province	1.56	1.5	36	28	60	0.626	260
5	Construction and Research of Post-TEM Course in CBI Perspective for Independent College CET-4	1.00	0.8	24	22	40	0.235	55
6	Research on Financing of Elderly Real Estate in Fujian	2.08	1.95	36	34	60	3.327	260

	Province based on REITs							
7	Research on High-precision Artificial Corneal Ultrasound Circumcision System	10	8.2	36	35	60	4.943	280
8	Research on Hot Event Propagation and Evolution in Social Networks Based on Game Theory and SIRS	7	6.44	36	30	60	4.093	320
9	Research on the Operation Mechanism of Deep Cooperation and Collaborative Education between Schools and Enterprises based on Knowledge Supply Chain	0.3	0.3	24	21	60	2.616	75
… …	… …	… …	… …	… …	… …	… …	… …	… …
585	Research on Geological Disaster Early Warning and Control Management Mechanism in Coastal Areas of Fujian Province Based on Deep Learning	1	0.6	36	36	80	4.56	260

Regarding the main factors that affect research project management, four key evaluation indicators are selected: funding completion rate, research progress, achievement level, and intrinsic performance. These factors are represented by corresponding indexes to indicate their impact on project performance. The score for intrinsic performance is calculated according to the "Performance Assessment and Reward Plan for the Intrinsic Development of Chengyi College, Jimei University". Research progress is measured by integrating the planned cycle and the actual completion cycle, with the actual completion time based on the date of publication of the results that meet the project completion conditions. Achievement level is measured by considering the publication level and impact factor of the publications in which the results are published.

In order to eliminate the dimensionality relationship between the aforementioned indicators and enable comparison and analysis on the same scale, normalization operations should be conducted. This helps simplify data processing and model building processes, and enhances understanding of the relationships between the data. When performing normalization, a mathematical method is usually used to map the values of the indicators to a specific range, such as 0 to 1 or -1 to 1. Common methods of normalization include Min-Max normalization and Standardization.[9]

Here, the normalization method we are using is standardization, which uses the mean and standard deviation of the indicators for conversion. Standardization allows the values of the indicators to conform to a normal distribution, with a mean of 0 and a standard deviation of 1. Standardization is suitable for situations where the data does not have an obvious range of minimum and maximum values, and it can better handle the dimensional differences between different indicators. Through normalization operations, the dimensionality relationship between different indicators can be eliminated, enabling comparison and analysis on the same scale. This helps improve the interpretability of the data and the expressiveness of the model, while also reducing dependence on raw data. For each indicator value x, equation (3) is used for transformation: [10]

$$z = \frac{x-mean}{std} \quad (3)$$

Where z represents the standardized value, mean is the mean value of the indicator, and std represents the standard deviation of the indicator.

Based on the calculation method described above, we have obtained project data with a total of 585 samples. We randomly select 450 samples as training samples and 135 samples as test samples. The target expected values are determined using expert scoring, as shown in Table 2 and Table 3.

Table 2. Training samples

No.	Project Title	Funding Completion Rate	Research Progress	Achievement Level	Intrinsic Performance	Expected Value
1	Research on the Occupational Psychological Maintenance and Professional Capacity Enhancement of University Counselors	-0.638	-0.566	0.424	0.064	-0.330
2	Study on the Impact of Technological Content Deepening in Export Trade Goods in Fujian Pilot Free Trade Zone	1.151	-1.925	-0.313	0.064	-0.471
3	Research on the Detailed Budgeting of Local Governments and Rule of Law Anti-Corruption	0.143	0.249	-0.313	0.064	0.066
4	Research on Current Status, Influencing Factors, and Upgrading Strategies of Export Product Structure in Fujian Province	0.811	-1.110	-0.845	0.064	-0.498

5	Construction and Research on Follow-up Courses for College English CET-4 from the Perspective of CBI	-0.873	0.249	-1.029	-0.847	-1.152
6	Research on Financing of Elderly Real Estate in Fujian Province based on REITs	0.560	0.521	0.423	0.064	0.723
7	Research on High-Precision Artificial Cornea Ultrasonic Loop Cutting System	-0.665	0.793	1.182	0.153	0.674
8	Research on the Spread and Evolution of Hot Events in Social Networks based on Game Theory and SIRS	0.378	-0.566	0.782	0.331	0.426
…	…	…	…	…	…	…
…	…	…	…	…	…	…
450	Research on Geological Disaster Early Warning and Control Management Mechanism in Coastal Areas of Fujian based on Deep Learning	-2.958	1.065	1.002	0.064	-0.382

Table 3. Test samples

No.	Project Title	Funding Completion Rate	Research Progress	Achievement Level	Intrinsic Performance	Expected Value
1	Exploration of the Path of Integration and Development of Sports in Higher Education and Community Sports in Overseas Chinese Homeland Xiamen	0.410	-0.566	-0.851	-0.825	-0.845
2	Study on Predicting Student Learning Behavior Based on BP Neural Network Algorithm	0.292	0.793	-1.026	-0.847	-0.363
3	Research on the Youth Responsibility Education Community in the New Era	-0.439	-0.023	-1.031	-0.847	-1.078

4	Research on Fuzzy Comprehensive Evaluation Method of Acoustic Comfort for Engineering Vehicles	0.914	0.249	-0.368	0.064	0.396
5	Research on Automatic Detection of Polyps in Capsule Endoscopy based on YOLOv3	-0.039	-2.197	0.028	-0.558	-1.275
6	Research on the Path to Enhance Patriotic Education for Youth in the Era of All-media	0.795	1.065	-0.360	0.064	0.721
…	…	…	…	…	…	…
…	…	…	…	…	…	…
135	Analysis of Model of Social Media Addiction and Positive Strategic Engagement in College Students	-0.178	1.065	-0.646	0.064	0.140

3.2 Environment settings

1) Determining the number of network layers. The number of layers in a BP neural network refers to the number of neuron layers, including the input layer, hidden layers, and output layer. Generally, the more layers a BP neural network has, the stronger its expressive ability, but it also increases the complexity and training difficulty of the network. In practical applications, it is common to choose a BP neural network with 2-3 layers. The model used in this study adopts a 3-layer structure.

2) Setting the number of neurons in each layer. The number of neurons in the input layer is 13, and the number of neurons in the output layer is 1. However, there is currently a lack of clear theory or research on determining the number of neurons in the hidden layer. Equation (4) is used as an empirical formula.

$$n=\sqrt{i+j}+a \tag{4}$$

Where a is a constant between 0 and 1; i is the number of neurons in the input layer; j is the number of neurons in the output layer; n is the number of neurons in the hidden layer. Empirically, the number of neurons in the hidden layer is determined to be between 4 and 14, and this study uses 14.

3) Setting the neuron activation function. The neuron activation function commonly used in BP neural networks is the sigmoid function, also known as the logistic function. The formula for this function is equation (5).

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

Where x represents the weighted sum of inputs and e represents the natural constant. The sigmoid function's output value ranges from 0 to 1, making it commonly used in the output layer of binary classification problems.

4) Setting the population size to 38, crossover rate to 0.8, mutation rate to 0.06, learning rate to 0.012, maximum iteration count to 10000, and number of generations to 60. Through genetic algorithm, continuously optimizing the weights and biases of the BP neural network to improve its performance and convergence speed.

3.3 Analysis of Experimental Results

Comparing the results of the traditional BP neural network and the BP neural network improved by genetic algorithm, as shown in Figure 2 and Figure 3. The comparison of their relative errors is shown in Table 4.

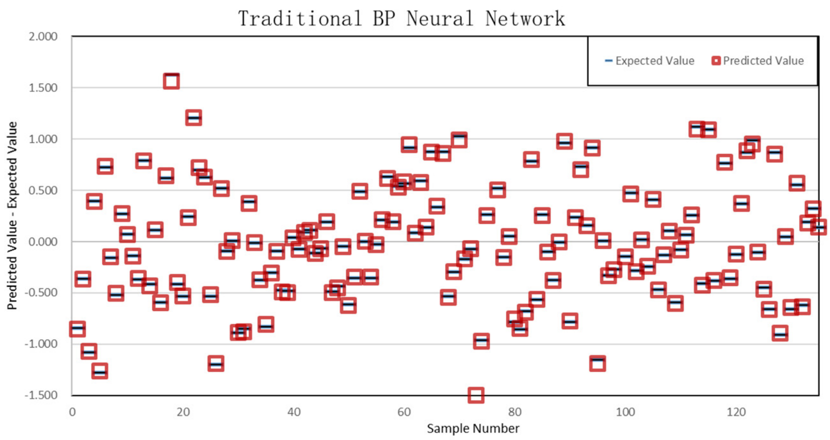

Fig. 2. Results of BP neural network testing

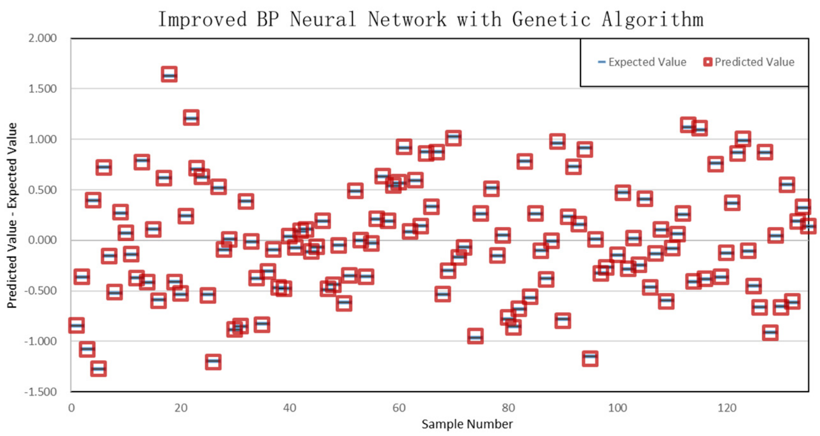

Fig. 3. Results of genetic algorithm improved BP neural network testing

Table 4. Comparison of relative errors before and after genetic algorithm improvement

No.	1	2	3	4	5	6	…	135
Traditional BP	0.97%	1.30%	-0.64%	-1.32%	-0.89%	1.54%	…	-1.02%
Improved	-0.17%	0.19%	0.31%	-0.26%	-0.47%	0.14%	…	-0.11%

From the comparison of the chart results presented above, it is evident that the genetic algorithm improved BP neural network exhibits superior accuracy and performance in comparison to the traditional BP neural network.

The integration of the genetic algorithm into the BP neural network allows for the optimization of initial network weights and thresholds, leading to enhanced training and prediction capabilities. This synergistic approach leverages the strengths of both algorithms, overcoming the limitations of the traditional BP neural network in accurately evaluating the performance of university research project management.

The experimental results demonstrate the effectiveness of the proposed method in achieving higher evaluation accuracy and stronger non-linear fitting capability. This finding signifies the practical applicability of the genetic algorithm improved BP neural network for the performance evaluation of university research project management.

By utilizing this novel approach, decision-makers and stakeholders in university management can have access to a reliable and scientific basis for making informed decisions. The accurate evaluation of project management performance not only contributes to enhancing the overall project management level but also fosters the development of scientific research within the university.

4 Conclusion

The primary objective of this study was to optimize the BP neural network using a genetic algorithm and validate its effectiveness through experiments conducted with research project data obtained from Chengyi College, Jimei University. The obtained experimental results unequivocally indicate that the proposed improved BP neural network model exhibits higher accuracy in performance evaluation.

The successful integration of the genetic algorithm into the BP neural network has resulted in a more efficient and accurate model for evaluating the management of research projects. By leveraging the genetic algorithm's optimization capabilities, the initial network weights and thresholds are fine-tuned, leading to improved training and prediction performance. Consequently, this enhanced model offers a feasible and effective solution for evaluating the performance of research project management.

The findings of this study hold significant implications for the advancement of research project management in universities. The adoption of the genetic algorithm improved BP neural network model provides a scientific and rational decision-making basis for university administrators. The accurate assessment of performance enables administrators to identify areas of strength and weakness, facilitating proactive measures to enhance the overall management of research projects.

Moreover, the application of this model promotes continuous improvement in research project management within universities. By employing a reliable and effective performance evaluation tool, universities can optimize resource allocation, enhance collaboration among researchers, and drive innovation in scientific research. Ultimately, this contributes to the overall progress and development of the academic institution.

In summary, this study successfully optimized the BP neural network using a genetic algorithm and demonstrated its efficacy in evaluating research project management. This research outcome not only improves the performance evaluation process but also provides a solid foundation for evidence-based decision-making in university administration. The application of this model has the potential to foster a culture of excellence in research project management, ensuring continued growth and success in scientific endeavors.

Acknowledgments. This work is supported by the Transverse Scientific Research Project of Chengyi College, Jimei University (HX23003).

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