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Markup Decision-Making Model Based on Genetic Algorithm Optimization BP Network

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Abstract: The decision of project bidding project level, not only is the determining factor whether win the bid of the project and project implementation success or failure and the determinants of construction enterprises can profit. In order to quicken the bidding speed of construction enterprises and to raise the success rate of their price decision-making, a markup decision-making model was established based on the artificial intelligence techniques: genetic algorithm and BP network. The model was verified by use of the data from many successful bidding examples that were chosen as the samples. The accuracy rate of decision-making, the inference speed as well as the self-learning of the decision-making system of the present model were superior to those of the traditional artificial neural network methods. It might be helpful to the bidding of construction enterprises.

Key words: BP network, genetic algorithm, bidding, mark-up

BIDDING

In competitive tendering, bidding is a complex decision making process full of uncertainties, it contains two successive phases: Bidding and pricing decision-making. Bidding decision is when the contractor through extensive research on engineering contracting market, extensive collection of bidding information and carefully selected, determine the process suitable for the company's bidding project (Hu and Chen, 2008). Pricing decision-making is when the contractor decided to bid, after a series of calculation and evaluation analysis and determine the quotation process starting from the basic goal is to win the bid and profitable (Yu, 2009). Bidding quotation includes three aspects: First, the bid or not. According to the project subject to bidding to decide whether to bid; second, determine the price. If the bidding and quotation; third, the bidding strategy and skill. However, reasonable prices play a decisive role in engineering bidding. Mainly displays in: The bidding is the foundation of contract negotiation, the bidding decides the project can profit or loss, the risk of project implementation, the nature of project change, the bidding can reserve claim opportunity, the damage of bidding in the project practice is irreversible, the bidding is an important factor in the success of the project (Cai *et al*., 2010).

At present, the definition of a widely quoted, the equation is:

$$\text{Price} = \text{Cost estimate price}\times(1+\text{mark-up}) \quad (1)$$

Cost estimate price refers to the basis the construction cost of construction enterprise quota estimation.

Kim *et al*. (2004) Mark-up refers to the ratio of project profit and risk premium and accounts for the cost. Profit for owners is the allowed profit, the bidders are calculated profit. Risk premium for contractors is an undetermined number, if not all the expected risk occurs, there may be residual risk premium reserve, this part of the surplus and profit plan together is the surplus, if the risk premium underestimated, the profits are used to subsidize. In the bidding, risk premium is closely linked for the contractor whether win the bid and the profit level after the bid, therefore, determine the mark-up scientifically is an important decision of the contractor:

$$\text{Mark-up} = \frac{\text{Bidding-cost estimate price}}{\text{Cost estimate price}} \quad (2)$$

ANALYSIS OF FACTORS INFLUENCING MARK-UP

Factors influencing mark-up is divided into three categories according to the characteristics of the project submitted to the mark-up: Environmental factors, factors of enterprises and factors of project, these three factors can be subdivided into 20 factors (Setyawati *et al*., 2002) (Fig. 1).

In the above influencing factors, some factors are quantifiable factors, such as the demand for funds, duration, management fees and the rate of return but some of these factors is difficult to quantify, such as location, quality of workers (He *et al*., 2012). Using the rating score way to quantify those elements that are not easily quantifiable, as shown in Table 1.

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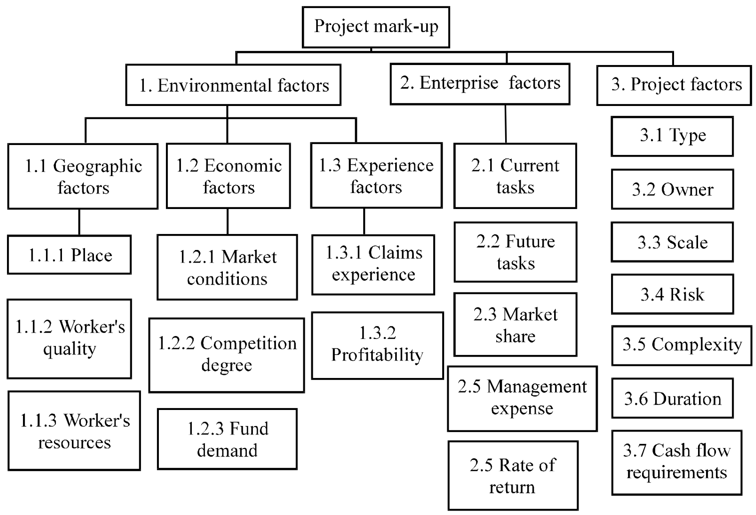

Fig. 1: Factors influencing mark-up

Table 1: Index of factors

Factors	Factors described	Index
Loacation	Whether the project located in the area	Y = 10, N = 0
Worker quality	Skill levels of workers	Good = 10, Ordinary = 5, Poor = 0
Worker resources	Easiness to hire local workers	Easy = 10, Hard = 5, Cannot = 0
Market conditions	Market improve effectiveness	High = 10, Ordinary = 5, Low = 0
Degree of competition	The No. of participating in the project bidding competitive bidders	The No. of contenders
Funding requirements	The funds required for the project	Ten million yuan
Profitability	Average percentage of profits on similar projects in the past	%
Claims experience	Failures in the past in similar projects or similar owners	Much = 10, Few = 5, None = 0
Current task	The total No. of enterprise projects currently under construction	High = 10, Ordinary = 5, Low = 0
Future task	Predict the No. of upcoming projects	High = 10, Ordinary = 5, Low = 0
Return rate	The rate of return determined based on the input of the enterprise	%
Market share	The ratio of actual market share	%
Management fees	Indirect management fees recovered this year	%
Type	Weather the project is within the scope of the enterprise	Y = 10, N = 0
Scale	The value of the contract after the valuation	Ten million yuan
Owner	The relationship between enterprises and the owners	Good = 10, Ordinary = 5, Low = 0
Other risks	Risk factors of the project contains and impact on project outcomes	Good = 10, Ordinary = 5, Low = 0
Complexity	Weather the complexity of the project is beyond the ability of enterprises	Good = 10, Ordinary = 5, Low = 0
Duration	The desired project	Month
Demand for cash flow	Average cash requirements of each period	Ten million yuan

GENETIC ALGORITHM-BP NETWORK DESIGN

Genetic algorithm is a global optimization algorithm based on Optimization but there is insufficient local optimization problem (Luo, 2005). In the early stage of searching for the optimal solution in the solution space based on the genetic algorithm, the speed of convergence is fast. But when it is close to the optimal solution, the solution would not converge for long due to the stochastic crossover operation and there is error bisect (Zhou *et al*., 2012). While the speed of convergence of searching for the optimal solution in the solution space is slow based on BP network, when it is close to the optimal solution, because gradient descent method is used and there is a direction, the local optimal searching is more efficient than genetic algorithm. Therefore, the combination of the genetic algorithm and BP network is meaningful. Not only can play the generalization ability of neural network and it converges very fast and has a strong learning ability. There are two ways of genetic algorithm and network, one is used for network training, meaning to learn the connection weights between network layer, the other is to learn the topological structure of network. It is the former that the genetic network is applied which optimize network connection weights by genetic algorithm.

Genetic algorithm design:

- **Initial population:** The original population size is set to 60. The experiments show that we can not only guarantee the search efficiency but also achieve global optimization search

- **Encoding:** A real number coding scheme is selected that each connection weights is directly represented by a real number. The advantages of real number coding scheme is that it is very intuitive and does not appear the lack of precision
- **Fitness function:** One important performance of BP network is the error sum of square between network's output value and desired output. The smaller the error sum of square is, the better the network performance is. So fitness function can be defined as:

$$f = \frac{1}{\sum_{i=1}^{n} e_i^2}$$

In which the denominator is the error sum of square between network's output value and desired output

- **Genetic operator:** The genetic algorithm consists of three basic operators: Selection, crossover and mutation

BP neural network structure design:

- **Network layers:** Choose a three-layers BP network based on Kolmogrov theory
- **No. of input layer nodes:** Due to the correspondence of the number of input layer nodes and mark-up influence factors, the input node number is determined to be 20
- **No. of output layer nodes:** The output result is required to be the markup of proposed tender, in which the number of output layer nodes is 1
- **No. of hidden layer nodes:** Through experimental methods, considering the network training speed and generalization ability, the number of hidden layer nodes is 14
- **Transmission function:** The transmission function of the hidden layer nodes should be set to the igmoid type. The activation function of the output layer node should be set to linear activation function BP network structure is shown in Fig. 2

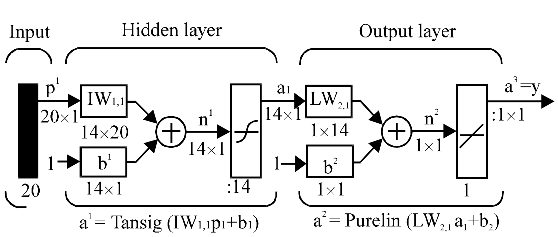

Fig. 2: BP network structure

ESTABLISHMENT AND IMPLEMENTATION OF MODEL

Implementation of software environment: According to the characteristics and scale of the mode, MATLAB is selected as the software environment of implementation of the model. The genetic algorithm toolbox (GOAT) was developed in the MATLAB environment by Christopher R. Houck, Jeffery A. Joines and Michael G. Kay of North Carolina State University, based on genetic algorithm theory. A three-layers genetic BP neural network model can be constructed only by calling several simple initialization statements in MATLAB. Programming ideas are shown in Fig. 3.

Model checking: Collecting various factors of thirty past successful tender offer programs from an international contracting company and quantify the factors with the quantitative method raised in the Table 1. Quantitative results are shown in Table 2 and 3. Thirty training samples quantized from the programs are divided into two groups: 25 for training artificial neural network and 5 used to verify the artificial neural networks.

Based on the genetic-BP neural network program designed in MATLAB environment, the above samples are trained, simulated and tested. Simulation process and simulation results are as follows:

Table 4 is the simulation results from the neural network trained by genetic neural network algorithm. Analyzing from the error of the results, the error is in line with the requirements.

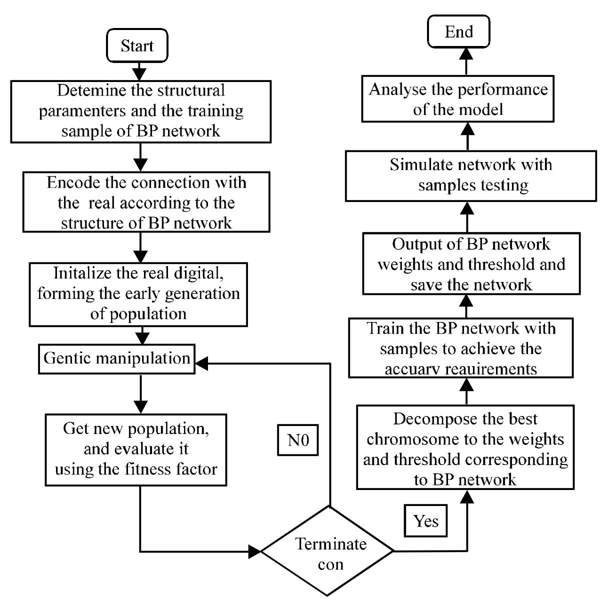

Fig. 3: Programming ideas

Table 2: Sample data

Serial No.	Place	Worker's quality	Worker's resources	Market conditions	Degree of competition	Capital requirement (kW)	Profitability (%)	Claims experience	Current task	Return rate (%)
1	10	10	5	5	4	2.4	11.2	5	0	8.2
2	10	10	10	0	9	6.1	15.6	0	5	7.9
3	10	5	5	10	7	4.3	14.6	0	0	6.2
4	10	5	5	5	6	3.3	13.8	5	5	8.6
5	10	10	10	10	4	5.9	18.2	0	5	7.8
6	10	10	10	5	5	7.4	15.6	0	0	6.9
7	10	10	5	10	8	5.0	14.9	0	0	7.3
8	0	10	10	10	6	4.4	15.8	5	5	7.5
9	10	5	5	10	7	4.0	16.7	5	0	8.5
10	10	5	5	10	5	3.1	15.2	0	5	7.9
11	10	10	10	10	6	4.9	16.5	0	0	6.8
12	0	5	10	10	5	1.7	15.7	0	5	6.7
13	10	10	10	5	6	2.6	16.9	5	0	8.9
14	10	10	5	10	7	2.3	14.8	0	0	8.5
15	0	10	10	10	5	3.3	16.3	0	0	8.4
16	10	10	10	5	6	3.0	16.5	5	5	7.6
17	10	5	10	5	7	2.6	17.8	5	0	7.4
18	0	5	5	10	4	3.2	19.5	0	5	6.7
19	10	10	10	10	5	5.0	18.4	0	0	8.2
20	10	5	5	5	6	3.9	17.5	0	0	9.4
21	0	10	5	10	5	2.7	16.5	0	0	8.5
22	10	5	10	10	6	3.6	18.4	0	0	8.6
23	10	5	10	10	4	4.8	19.0	5	0	7.8
24	10	10	5	0	9	4.0	17.4	5	0	9.5
25	0	10	10	10	2	3.0	18.2	5	0	8.5
26	10	10	5	5	6	3.3	18.5	0	5	8.6
27	10	5	10	0	7	3.0	18.3	0	0	7.9
28	10	5	5	10	4	2.6	17.2	0	0	6.9
29	10	10	5	5	5	3.8	18.5	0	0	6.7
30	10	10	10	10	6	4.1	19.6	0	0	8.3

Table 3: Sample data

Serial No.	Market share (%)	Management expense (%)	Scale kW	Type	The future task	Owner	Risk	Complexity	The duration (days)	Cash flow (kW)	Mark-up (%)
1	8.9	3.7	2.3	10	5	10	5	0	14	2.30	6.4
2	8.6	6.3	6.0	10	0	10	5	5.	15	5.24	7.6
3	9.2	4.5	4.2	0	10	5	0	0	21	3.05	8.0
4	9.3	5.0	3.2	10	5	5	5	5	20	2.50	7.4
5	8.8	5.2	5.8	10	10	10	0	5	15	2.25	7.2
6	8.6	6.3	7.3	0	5	10	10	5	23	8.32	8.3
7	9.8	4.2	4.9	10	10	10	5	0	24	2.50	6.8
8	9.7	5.2	4.3	10	10	10	0	0	11	3.27	7.6
9	9.6	4.8	3.9	0	10	5	0	5	20	3.50	7.9
10	8.5	4.7	3.0	10	10	5	5	5	21	2.70	7.1
11	7.9	5.2	4.8	0	10	10	0	0	18	3.57	8.2
12	7.8	4.5	1.6	10	10	10	0	0	19	0.98	7.8
13	9.8	5.3	2.5	10	5	5	0	0	17	1.54	6.9
14	9.6	4.3	2.2	10	10	10	0	0	21	0.85	7.2
15	8.6	5.3	3.2	10	10	10	0	5	15	2.57	7.8
16	8.7	3.2	2.9	10	5	5	5	5	21	3.21	7.2
17	7.9	4.3	2.5	10	5	10	0	0	23	1.05	6.4
18	7.8	2.5	3.3	0	10	10	0	5	20	2.93	8.2
19	9.6	3.6	4.9	10	10	10	5	0	25	3.20	7.2
20	8.7	2.0	3.8	10	5	5	5	5	26	3.75	6.8
21	9.3	1.8	2.6	10	10	5	5	10	27	1.10	6.2
22	9.2	3.0	3.5	10	10	10	5	5	25	2.50	7.5
23	8.6	4.2	4.7	10	10	5	0	10	22	3.60	7.9
24	7.8	5.9	3.9	10	0	5	0	10	13	4.62	6.5
25	9.3	3.6	2.9	10	10	10	0	5.	16	3.25	7.9
26	9.4	3.2	3.2	10	5	10	5	5	18	2.35	7.1
27	8.6	3.7	2.9	10	0	5	5	10	16	4.20	6.2
28	8.9	2.8	2.5	10	10	5	0	10	25	2.18	5.7
29	8.6	3.1	3.7	10	5	5	0	10	26	3.90	6.4
30	9.0	2.8	4.0	10	10	10	5	5	30	3.42	7.6

Table 4: Simulation results (%)

Serial No.	26	27	28	29	30
Mark-up					
Estimated value	7.2881	7.0706	7.3285	6.4633	7.3679
The actual value	7.1000	6.2000	5.7000	6.4000	7.6000
Absolute error	0.1881	0.8706	1.6285	0.0633	0.2321

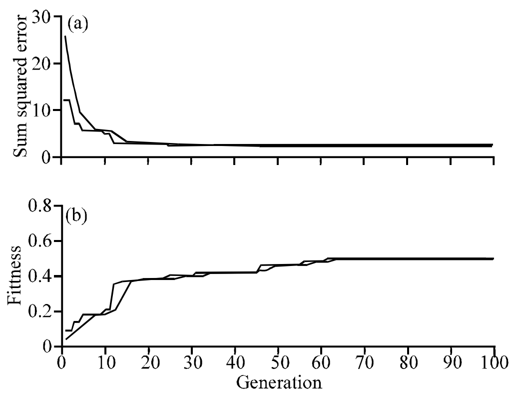

Fig. 4: Operation trajectory genetic algorithm

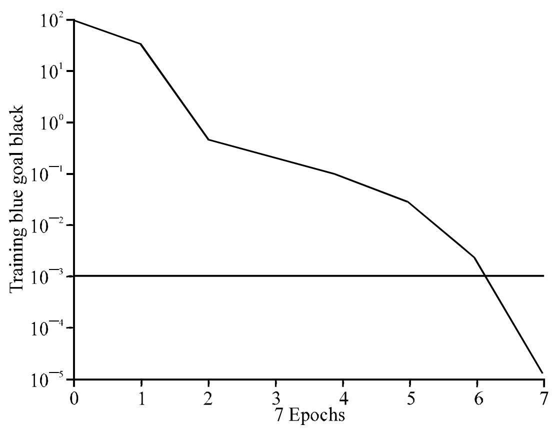

Fig. 5: Training process of neural networks

Figure 4 is the computation trajectory of the part of genetic algorithm in the genetic neural network algorithm. From the figure we can see, the fitness value of chromosome after the 80th generations is basically stable at about 0.5.

Figure 5 is the secondary training process of the neural network in genetic neural network algorithm. The training process indicates that the sample is only trained 7 steps to achieve the accuracy requirements.

CONCLUSION

On the basis of the constitution of engineering project bidding, the key of bidding process is to determine the make-up and analysis the influencing factors of make-up. According to the complexity, uncertainty and other characteristics of the decision of engineering project bidding, the idea that combining advantage with the BP neural network and genetic algorithm is raised to establish the make-up decision-making model of genetic-BP neural network. From the view of the implementation of the model, good results has achieved in the aspects of decision-making accuracy rate, the reasoning speed and self-learning of decision-making system.

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