

The evaluation system of green mining based on quantum immune algorithm and neural network

Zhong Dongwang^{1, a}, Li Linna^{1, b}

¹ The College of Science, Wuhan University of Science and Technology, Wuhan 430065, China

^azhongdw123@263.net, ^blinda020329@163.com

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Abstract. The construction of green mine represents the development and utilization level of mineral resources and the sustainable development potential. In view of the characteristics of the large index system and complex evaluation process of green mining, a kind of BP neural network algorithm based on quantum immune apply to green mining evaluation. Because the algorithm combines the space search advantages of immune optimization and those of quantum optimization, it can make the convergence of the neural network training faster, and avoid falling into local optimum.

Introduction

Mineral resources are the important material base of society survival and development and one of the determinant of country be more prosperous and great, but it is a kind of non-renewable resources. Because of the large population and relatively insufficient resources, our country must implement the strategy of sustainable development in the modernization drive. As a new development model, green mining is the application of the sustainable development strategy in mine construction, and it will apply environmental strategy of overall prevention to the whole process of mine construction and production. At the same time it considers the economic benefits and environmental benefits.

The construction of green mine represents the development and utilization level of mineral resources and the sustainable development potential. Because it focuses on the sustainable development of ecological benefits, economic benefits and social benefits, and gives full consideration to the factors of mineral resources consumption and environmental control, the green mining construction become development and utilization of mineral resources which has higher quality and efficiency, instead of the traditional sense of the development and utilization of mineral resources which destroy the ecological environment and consume the mineral resources. The evaluation of the sustainable development level, namely how to evaluate the health of mine system, is an important research field on green mine construction. Green mining evaluation is comprehensive analysis to the mining economy in the past, present and future, using multidisciplinary, multiple means and various information. Exploring the evaluation method of the green mining is of great significance to realize the level of sustainable development of mining economy in China^[1].

the evaluation system of green mining

The index system of green mining

We need some specific characteristics to reflect the state of mine sustainable development, namely we must characterize the health by a specific index, so the index system plays an important role of monitor. Based on the in-depth analysis to the connotation of mining sustainable development and the structure of mining system, we can find out all kinds of features which can represent health the level of mine construction development, and finish the quantitative process of the healthy development evaluation of mining. Those provide the necessary basic data for research on the evaluate model.

By the analysis to the connotation and mechanism of mine sustainable development, and following the principle of index system building, the evaluation index system is constituted of the management by law, development and utilization of resources, scientific and technological innovation, environmental protection and social economic, as shown in table 1.

- (1) the target layer: the highest level of the index system, it is the overall goal of health evaluation.
- (2) the rule layer: the main system level of the index system, it ensure to realize the overall goal.
- (3) the index layer: the most basic level of the index system, it include all specific indicators of health assessment, that are directly measurable factors.

Table 1 The evaluation index system of green mining

target layer	rule layer	index layer
The evaluation index system of green mining	management by law	A1 the number of legal license
		A2 the amount of paying taxes and deposit
		A3 the rate of production safety accidents
		A4 the punishment of production safety accident
	development and utilization of resources	B1 impoverishment rate in mining
		B2 recovery percentage
		B3 ore dressing recovery percentage
		B4 tailings utilization
		B5 comprehensive energy and water consumption/ten thousand yuan GDP
		B6 non-renewable energy consumption/ten thousand yuan GDP
		B7 comprehensive utilization rate of mineral resources
	scientific and technological innovation	C1 the proportion of science and technology innovation in total investment of the mine construction
		C2 the proportion of high and new technology of environmentally friendly technology
		C3 number of research reports
		C4 proportion of technical personnel
	environmental protection	D1 "three simultaneity" system enforced
		D2 water cycle utilization rate
		D3 clean energy utilization
		D4 "three wastes" success rate
		D5 noise pollution
		D6 rate of total discharge of major pollutants reduction
		D7 land reclamation rate
		D8 greening coverage
		D9 geological hazard control rate
		D10 proportion of Environmental protection investment
	social economic	E1 social accumulation rate
		E2 social contribution rate
		E3 proportion of indirect employment
		E4 proportion of direct employment
		E5 integrating degree between regions and enterprises

data preprocessing of index in the green mining evaluation system

In the evaluation standard of green mining sustainable development level, the original data is normalized processed by the following method:

Setting $X_i = (x_{i1}, x_{i2}, \dots, x_{i30})$ to diagnosis index vector, the index data is compressed to the interval $[0,1]$ by using extreme value standardization formula to normalized processing.

$$x = \frac{x' - x'_{\min}}{x'_{\max} - x'_{\min}} \quad (1)$$

x'_{\min} is the minimum of evaluation index, x'_{\max} is the maximum of evaluation index.

calculation——the evaluation model basing on quantum immune algorithm and neural network

Neural network can be used in the evaluation and prediction of many practical problems, but it is difficult to convergence in the evaluation system of green mining, because its index system is more complex and large, and the indexes hava inevitably link and overlap. So in this paper, an improved

algorithm of BP neural network based on quantum immune is put forward used for green mining evaluation. Combining the space search advantages of immune optimization and quantum optimization, the algorithm make the convergence of neural network training faster, and avoid it falling into local optimum^[2-4]. The implementation steps of algorithm are as follows:

Step1: Generate the initial population: N quantum antibodies are genenated which compose the initial population groups, where N is the weights of neural network;

Step2: Construct the fitness function: the error function based on BP neural network construct the chromosome fitness function;

Step3: Select operation: n antibodies with highest affinity are choosed from groups;

Step4: Cloning augmentation operation: the selected antibodies are expanded based on adaptive quantum revolving door;

Step5: Mutation operation: m antibodies with minimum affinity from population are mutated based on adaptive quantum revolving door;

Step6: Replace operation: the rotation Angles of quantum revolving door are adaptively adjusted, and the quantum antibody population is updated while the quantum gate applies to the probability amplitude all the individuals in the population;

Step7: Return to step 3 to loop compute, until meeting the convergence conditions or reaching the maximum limit of generation.

The neural network model which trained by the above algorithm, can be used in the evaluation system of green mining.

The simulation and the result analysis on the green mining evaluation system

There are 18 groups of index data applied to the experiments of mining evaluation, then those normalized to the standardization data and shown in table 2.

Each set of data including 30 evaluation indexes, become the input vector, and the green mining evaluation results are the output of network .The evaluation results with value range of [0, 1], are provided by experts according to the quantitative level and the scope of each level as shown in table 3, which show in table 4.

Table 2 the standardization index data of Green mine evaluation system

target layer	rule layer	index layer	mine 1	mine 2	mine 3	mine 4	mine 5	mine 6	mine 7	mine 8	mine 9	mine 10	mine 11	mine 12	mine 13	mine 14	mine 15
The evaluation index system of green mining	Management by law	A1	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		A2	0.5	0.59	0.4	0.7	0.63	0.8	0.76	0.78	0.9	0.88	0.8	0.85	0.91	0.9	0.96
		A3	0.6	0.55	0.6	0.4	0.45	0.4	0.4	0.43	0.25	0.3	0.375	0.3	0.35	0.3	0
		A4	0.55	0.6	0.75	0.4	0.36	0.3	0.37	0.33	0	0.1	0.2	0.2	0.2	0.25	0
	Development and utilization of resources	B1	0.55	0.55	0.6	0.5	0.4	0.2	0.5	0.3	0.15	0.15	0.25	0.2	0.15	0.2	0.14
		B2	0.55	0.58	0.45	0.6	0.65	0.8	0.75	0.72	0.78	0.8	0.76	0.88	0.9	0.8	0.92
		B3	0.55	0.59	0.5	0.6	0.63	0.8	0.75	0.74	0.88	0.85	0.75	0.89	0.9	0.8	0.91
		B4	0.24	0.24	0.18	0.3	0.3	0.4	0.35	0.33	0.35	0.4	0.35	0.45	0.48	0.4	0.51
		B5	1	0.8	0.9	0.8	0.8	0.6	0.5	0.55	0.4	0.35	0.5	0.3	0.25	0.4	0.245
		B6	0.55	0.52	0.65	0.5	0.45	0.4	0.4	0.42	0.39	0.38	0.7	0.35	0.3	0.35	0.25
		B7	0.45	0.49	0.35	0.5	0.55	0.8	0.68	0.67	0.72	0.75	0.7	0.76	0.78	0.75	0.81
	scientific and technological innovation	C1	0.18	0.19	0.12	0.2	0.25	0.5	0.34	0.32	0.36	0.38	0.35	0.4	0.45	0.4	0.52
		C2	0.7	0.74	0.5	0.8	0.8	0.9	0.85	0.84	0.85	0.88	0.85	0.9	0.94	0.9	1
		C3	0.2	0.24	0.2	0.3	0.3	0.5	0.4	0.4	0.4	0.44	0.4	0.45	0.475	0.45	0.55
		C4	0.35	0.39	0.25	0.4	0.4	0.7	0.6	0.55	0.6	0.65	0.6	0.7	0.75	0.65	0.76
	Environmental protection	D1	0.78	0.79	0.60	0.82	0.90	0.95	0.90	0.88	0.90	0.92	0.90	0.95	0.98	0.95	1.00
		D2	0.74	0.74	0.65	0.76	0.80	0.93	0.85	0.78	0.85	0.88	0.85	0.90	0.94	0.90	0.96
		D3	0.27	0.30	0.23	0.33	0.47	0.60	0.47	0.47	0.50	0.53	0.50	0.60	0.63	0.60	0.73
		D4	0.70	0.79	0.65	0.80	0.85	0.95	0.90	0.88	0.92	0.94	0.90	0.95	0.96	0.95	1.00
		D5	0.80	0.80	0.85	0.70	0.70	0.60	0.67	0.70	0.67	0.65	0.68	0.58	0.56	0.60	0.54
		D6	0.18	0.18	0.14	0.23	0.30	0.43	0.35	0.33	0.35	0.38	0.35	0.40	0.45	0.38	0.51
		D7	0.50	0.59	0.45	0.60	0.65	0.78	0.75	0.73	0.75	0.80	0.75	0.85	0.90	0.80	0.93
		D8	0.40	0.49	0.40	0.60	0.55	0.78	0.65	0.60	0.70	0.75	0.80	0.78	0.80	0.75	0.81
		D9	0.55	0.58	0.51	0.70	0.78	0.93	0.80	0.78	0.80	0.85	0.82	0.90	0.95	0.85	1.00
		D10	0.18	0.19	0.16	0.24	0.24	0.40	0.30	0.30	0.30	0.32	0.30	0.34	0.36	0.36	0.42
	social economic	E1	0.55	0.59	0.50	0.70	0.65	0.89	0.75	0.71	0.75	0.80	0.78	0.85	0.90	0.80	0.91
		E2	0.55	0.58	0.40	0.70	0.65	0.85	0.74	0.72	0.76	0.82	0.75	0.88	0.85	0.80	0.91
		E3	0.20	0.23	0.20	0.30	0.29	0.39	0.38	0.38	0.38	0.39	0.38	0.40	0.45	0.40	0.51
		E4	0.18	0.19	0.13	0.30	0.28	0.45	0.35	0.34	0.35	0.40	0.35	0.38	0.45	0.40	0.53
		E5	0.55	0.58	0.40	0.70	0.68	0.80	0.75	0.74	0.78	0.80	0.75	0.82	0.85	0.78	0.85

According to the sampling data of evaluation of green mining, we can determine that the input layer of the neural network contains 30 neurons and the output layer contains one neuron. Based on many experiments , the number of hidden layer neurons is 20, and the limit of error and iterations are 0.001, and 1000 respectively. Considering the performance of the evaluation network, we adopt the stochastic method to generate the training set and the test set, that is, randomly choose 12 samples from the 15 sets of data as training set, the remaining three as test set.

Table 3 the grade of evaluation and signal identification

grade	First grade	Second grade	Third grade	Forth grade
state	Green degree is very strong	Green degree is stronger	Green degree is medium	Green degree is weak
interval	[0.75,1]	[0.5,0.75)	[0.25,0.5)	[0,0.25)

Table 4 Green mining quantitative evaluation results

	mine1	mine 2	mine 3	mine 4	mine 5	mine 6	mine 7	mine 8
Evaluation value	0.24	0.23	0.25	0.45	0.44	0.48	0.43	0.45
grade	Forth grade	Forth grade	Third grade	Third grade	Third grade	Third grade	Third grade	Third grade
	mine 9	mine 10	mine 11	mine 12	mine 13	mine 14	mine 15	
Evaluation value	0.62	0.63	0.62	0.65	0.7	0.71	0.78	
grade	Second grade	Second grade	Second grade	Second grade	Second grade	Second grade	First grade	

The simulation hardware environment is Pentium IV / 2.4 GHz / 512 ram, and the simulation software platform are Windows XP operating system and the Matlab 6.5.

After the simulation test, the generalization ability of the network evaluated by the calculation to the deviation of predicted values and the real value in 10 times test, the evaluation results are shown in table 5.

Table 5 The results of the neural network training 10 times

Test times	result						The maximum error of the evaluation
	Quantitative results			results of network evaluation			
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	0.71	0.44	0.74	0.7243	0.4449	0.7330	0.0143
2	0.73	0.71	0.74	0.7332	0.7041	0.7462	0.0062
3	0.65	0.70	0.78	0.6515	0.7089	0.7996	0.0096
4	0.71	0.62	0.25	0.6968	0.6205	0.2407	0.0132
5	0.70	0.24	0.45	0.7148	0.2327	0.4406	0.0148
6	0.25	0.75	0.43	0.2610	0.7602	0.4192	0.0110
7	0.62	0.44	0.45	0.6145	0.4377	0.4618	0.0145
8	0.25	0.43	0.24	0.2591	0.4212	0.2273	0.0127
9	0.62	0.70	0.71	0.6379	0.7151	0.7054	0.0179
10	0.45	0.23	0.75	0.4521	0.2463	0.7375	0.0163

Because the training set and testing set are random, the result of each time will be different. One result is shown in Fig.1, and comparing the evaluation results and the actual data we can see that the neural network model based on quantum immune has faster convergence rate and stronger approximation ability than the BP neural network model .

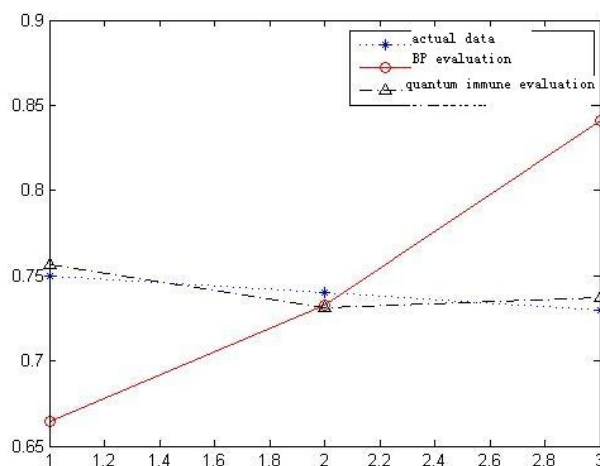


Figure 2 evaluation result contrast of green mining

Conclusion

Green mining evaluation belongs to the multi-variable, strong coupling and nonlinear prediction problem, and its complex mapping relation make the convergent of conventional algorithm is difficult, so this paper puts forward a comprehensive evaluation based on quantum immune algorithm and neural network, which not only has process mapping ability, but also has the high efficiency of quantum mechanism and global convergence of immune algorithm.

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