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Based on the Orthogonal Test Method Optimizing and Settings the Ant Colony Algorithm Parameters

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Abstract—In this paper, the influence on parameters of output performance of system is studied, the interaction among the various parameters is analyzed. The main parameters of ant colony algorithm are optimized through orthogonal tests, at the same times the ant colony optimization algorithm's parameters to output performance influences of the wavelet network are discussed. From results it is that the number of test parameter setting is reduced, the best parameters combination scheme is found, the subjectivity problem in the process of set parameters is overcome, the parameter selection efficiency is improved.

Keywords-0rthogonal test method; Optimize Setting; Ant colony algorithm; Wavelet Network

1. Introduction

The orthogonal test method is a test method , it uses the orthogonal table to deal with the tests, and using the orthogonal table characteristics to calculate、analyze, so finding out the optimum test way. It is a kind of incomplete experimental design, in the properties nature , it applies to multi-factor, multiple indicator, with random errors of the trial. By the orthogonal test, which can effectively analyze the impact of factors on the test targets, identify the primary and secondary relationships in accordance with their importance extent, and determine the optimal conditions of test criteria. The full factorial experiment is an experiment by taking into account all the factors involved, and verified by experiments , so it can provide a very comprehensive reference, but rather spend time and money. For example the full factorial experiments containing 13 factors, each with 3 levels were required to do 3^{13} times. Assuming that each experiment took 3min, daily 8h, 250 wording days in one year, the experiments will be 40 years, it is simply impossible in the actual living[1].

2. Parameters optimal configuration in the Ant colony

- The ant colony algorithm parameters have different degrees impact in terms of performance[2]. The parameter a value remains the importance level in the amount of information each node: a value is of larger means the ants select the passing route's likelihood is greater, but it is too larger to cause search prematurely trapped in local minimum solution.
- The parameter β size indicates the degree of importance attached to heuristic information: β value larger means the ants choose a shorter distance city's possibility is greater. The parameter ρ shows the pheromone's retention rate, if its value is improper, and the result will be poor.
- The parameter Q is the system initialization parameters, it shows the initial energy of the system. If it is number value is relatively small, it will lead to the pheromone intensity of some paths to become very small as the system's ongoing evolution, so it isn't conducive to the computer's calculations, and

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also it effects the system to search. Generally the parameter increases the number value on the basis of the scale expansion of the problem, especially in high-dimensional, and more complex issues, Q number value can not be ignored. The system has multi-channel automatic alarm function. Based on the results, such as abnormal grain situation, the system can give alarms through screen display, text messages and BP machine, and then save and print these alarms automatically.

- The parameter m stands for the number of ants of the system, usually it is the number of cities around 0.6 to 1 times. If there are too many ants, it could make the pheromone strength on some local path over-concentration, cause the system select the lower probability of other paths, turning up the system precocious phenomenon; If the ants numbers is small, it can not add the pheromone intensity gradually evaporate, because no one is interested on some paths, so causing the system's search narrow and eventually causing the system's search to be failures [3].
- Based on the above analysis, if the parameters a、β、ρ、Q、m set up properly, easily lead to solving very slow and the particularly poor quality. So the parameters a、β、ρ、Q、m best configuration's study has very important meaning on the ant colony algorithm to play a role in the actual problem.

3. Based on the orthogonal test method's ant colony algorithm parameter Settings

In order to obtain the optimum parameters settings, usually we need to do many factorial experiments on the ant colony algorithm's main parameters. When factors are more, if we adopt the comprehensive test methods, the tests will be done many times, the maneuverability is low. Based on orthogonal test methods of ant colony algorithm, the main parameters are optimized, thereby reducing the number of test parameter settings, searching the optimal parameter combination scheme, overcoming the problem in the process of parameter setting, improving the parameter selection efficiency.

In ant colony algorithm, the parameter settings influence it's solving performance and efficiency. The pheromones residual factor $^{1-\rho}$、pheromones heuristic factor α、expect stimulating factor β、pheromone strength ^{Q} and ants number m etc are very important parameters, the selection method and principles affect directly the ant colony algorithm global convergence[4]. Due to the ant colony algorithm parameters of large space and the connection among the various parameters, and how to determine the optimal combination of ant colony algorithm parameters has been the best performance is a complicated optimization problems. In most cases it is based on experience together and try again.

The parameter optimization settings's main steps:

3.1 Determining the test objective and index

In the concrete work, the problems are often more complex. Usually impossible all problems are solved in a test, therefore, determining the test purpose becomes the key points, and the corresponding test index is confirmed. In this paper, the shortest path length serve as test index, the ant colony algorithm's parameters setting method is studied.

3.2 Choosing the factors and level

After the index was confirmed, the influence of these index various factors are analyzed, the little impact on indicators or having mastered better factors are excluded, then these factors are fixed on an appropriate level. Firstly, according to the principle of muli-choice factors and less level, through the first trials, the development trend of change various factor levels and the major factor are found. Then, the main factors are further discussed on the more level. In this paper, the parameters of ant colony algorithm serve as different test factors, and confirming the different factors levels.

3.3 Designing the interaction column and the pian.

The selected various factors will be set respectively on the proper orthogonal listed head. After the factors in each column were arranged, the level numbers of each column in the list would be replaced with the actual level of factors.

3.4 Analyzing the experimental results

By extreme deviation method and variance analysis method, working out the various factors on the test index's influence and the optimum combination test condition. If the best test parameters scheme condition isn't appear in the testing program, using the optimum combination test condition goes ahead verification test.

4. Simulation test and the results analysis

Through the tests ,four empirical data of the ant colony optimization algorithm were obtained: The ratio of the goal nodes and the number of ants is 1.5 determines the number of ants; The pheromone strength $Q < 1000$ hasn't too much influence on the general solution properties of ant colony algorithm; As information heuristic factor $a = 0$ or expect stimulating factor $\beta = 0$, the global convergence properties of ant colony algorithm will seriously deteriorating, Pheromones volatile factor $\rho = 0$ will easy cause the residual pheromone overmuch ,thus it will submerge the elicitation information[5].

In this paper, based on the above parameters settings experience, the ant colony optimization parameters $\alpha(0 < a \le 5)$, $\beta(0 < \beta \le 5)$, $\rho_{\min}(0.001 \le \rho_{\min} \le 0.5)$ influence the output performance was discussed, those parameters are based on ant colony optimization algorithm of wavelet learning neural network. In addition, because choice directly relate to the divert probability of ant colony, α 、 β interaction are analyzed in experimental.

In the test design, the different levels identification errors of the wavelet network fault diagnosis system's parameters serve as the test index. The parameters α、β、$\rho_{\min}$ factors and level are shown in table 1 in the testing program.

Table1. THE PARAMETERS FACTORS AND LEVEL

Factors / Level	A(a)	B(β)	C($\rho_{\min}$)
1	1	1	0.001
2	2	2	0.1
3	4	4	0.3
4	5	5	0.5

Due to the level is four, the interaction $(A \times B)$ has three column, they are $(A \times B)1$ 、 $(A \times B)2$ 、 $(A \times B)3$ respectively. Therefore, in the testing program's table header , factor A and B and A×B interaction altogether six columns. According to the interaction between two lists， analyzing the factors A、B、C and the interaction between A×B, designing corresponding factors header are shown in table 2:

Table2. THE INTERACTIVE ELEMENT HEADER DESIGN PROPOSAL

Factors	A	B	C	(A×B)1	(A×B)2	(A×B)3
list	1	2	5	3	4	5

In SPSS13 software, using orthogonal design functions design the orthogonal testing proposal for the various factors in table 2, obtaining $L_{30}(4^9)$ .Making use of $L_{30}(4^9)$ design proposal， 30 times test are finished for wavelet network, and the network error output results will be as indexes, the analysis results are shown in table 3.

Table3. THE VARIANCE ANALYSIS OF OUTPUT RESULTS

Source	Mean Square	F	Sig.
A	.063	10.54	.001
B	.001	.140	.934
C	.004	.723	.566
$(A \times B)_1$	.001	.129	.941
$(A \times B)_2$	.018	3.071	.065

$(A\times B)_3$	.000	.032	.991

Due to the benchmark index is error, the smaller the index value is, the better the result is. From the table 4, the average value of various factors in different levels and extreme value W analysis show that the pheromone stimulating factor level is of choosing best level: it's A1; The pheromones volatile factor takes C3 is the best. By extreme value W analysis, the factor B to the error of the output influence is smaller than the A and B factors $(A\times B)2$ .The selection of B is determined according to A and B collocation $A_1B_i, i=1,2,3,4$.

Table4. THE FACTORS AND THEIR INTERACTION STATISTICAL SCALE

Factors and interaction	**level**	**Mean**	**W**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
A	1	.122	0.206	.062	.181
	2	.260		.201	.318
	3	.284		.226	.344
	4	.328		.268	.387
B	1	.253	0.023	.194	.312
	2	.233		.174	.293
	3	.252		.192	.310
	4	.256		.196	.315
C	1	.276	0.053	.218	.337
	2	.237		.178	.296
	3	.224		.165	.282
	4	.255		.196	.315
(A×B)1	1	.234	0.022	.175	.293
	2	.256		.196	.315
	3	.251		.192	.310
	4	.253		.194	.312
(A×B)2	1	.273	0.104	.214	.332
	2	.198		.140	.258
	3	.219		.160	.278
	4	.303		.244	.362
(A×B)3	1	.250	0.011	.191	.308
	2	.251		.191	.310
	3	.241		.182	.300
	4	.252		.193	.311

From the table 5, as A1B2 collocation, the output error is smallest. Therefore, B2 is the best.

Table5. THE SCALE FACTOR COLLOCATION UPON A,B INTERACTION

(A×B)2	**A1B1**	**A1B2**	**A1B3**	**A1B4**
Mean	0.1398	0.0009	0.1995	0.0508
$(A\times B)_2$	A_2B_1	A_2B_2	A_2B_3	A_2B_4
Mean	0.2513	0.2400	0.2612	0.2860
$(A\times B)_2$	A_3B_1	A_3B_2	A_3B_3	A_3B_4
Mean	0.3209	0.2225	0.2898	0.3054
$(A\times B)_2$	A_4B_1	A_4B_2	A_4B_3	A_4B_4
Mean	0.3036	0.3748	0.2530	0.3825

The experiment results show the optimum condition of minimum error output is A1B2C3.That is :The pheromone stimulating factor levels choice the first level is best, namely $A1(\alpha = 1)$;The expect stimulating factor choice the second level is optimum, namely $B2(\beta = 2)$;The pheromones volatile factor select third levels is best, namely the $C3(\rho_{\min} = 0.2)$.

5. Conclusions

The subjectivity questions of the test parameters are reduce effectively because of the ant colony algorithm parameters set by the orthogonal design. In conventional experiments, the parameter setting process is mainly artificial experience, so the experiments have strong randomness and subjectivity, not conducive to objective analysis the experimental results. If you need an objective response parameter is reasonable, a comprehensive test must be done. However, the comprehensive test will appear exponential growth with the parameters growth. In this testing project design, the comprehensive tests need to be done 4096 times, While using the proposed orthogonal test design method to go ahead the optimized parameters settings, the test number is only 30. Thus the number of network tests greatly were reduced, the parameters selection's testing period was cut down.

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