Water Resources Allocation Effect Evaluation Based on Chaotic Neural Network Model

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***Abstract*—Aiming at the problems such as peoples' influence, the poor objectivity and comparability of traditional evaluation methods, a chaotic neural network comprehensive evaluation model is established, coupled the ergodicity characteristic of chaotic motion with the neural network. In the model, chaotic learning algorithm is constructed, the sequences are generated by chaotic maps to guide the search process to achieve optimization problem in limited range, the neural network algorithm is adopted to achieve fast optimization extreme in the range of each local interval, and the elitist strategy is used to make the algorithm converge to the global optimization. An example of the effect evaluation of water resources allocation is studied with the model, which shows that the model is simpler in principle, more convenient in calculation, more accurate for results, and it has strong adaptability and replicability.**

***Index Terms*-chaotic neural network, comprehensive evaluation model, water resources allocation, effect evaluation, index system, entropy**

I. INTRODUCTION

In recent years, more and more experiments show that chaos phenomenon exists in human brain. Chaos theory may explain some abnormal activities in human brain. Therefore, the chaos theory can provide people with new ways to study neural network, and then chaotic neural network(CNN) comes into being. Aihara discovered the chaos phenomenon in HH equation numerical analysis, Brain magnetic field test and also ANN research and presented the first chaotic neural network model[1]. The application of CNN in recent years, has received considerable attention. It has applied research in areas such as information generation, pattern recognition, associative memory, voice memory, voice recognition, computer graphics, and so on[2,3]. But literature about CNN which is applied to comprehensive evaluation system is still rare.

Currently, there are dozens of commonly used evaluation methods. Among them, the most frequently used are analytic hierarchy process(AHP)[4], fuzzy comprehensive evaluation(FCE)[5], set pair analysis(SPA)[6], gray relative evaluation (GRE)[7], projection pursuit(PP)[8], data envelopment analysis(DEA)[9], entropy evaluation(EE)[10], synergetics evaluation(SE)[11], artificial neural networks(ANN)[12] and so on. Because of influences caused by incertitude factors, the evaluation results of these evaluation methods are always with a personal bias and one-sidedness, subjective appraisal. Based on the characteristics of chaotic motion, we couple the chaos theory with neural networks and propose Chaos Neural Networks Comprehensive Evaluation, which can conduct comprehensive evaluation of effects of water resources allocation. The method takes full advantage of ergodicity of chaotic motion and the ability of neural networks to handle complex non-linear mapping. Thus, it improves the efficiency of algorithm, strengthens objectivity of the evaluate results and also has strong adaptability and generalizability

The sign of chaos theory is the paper Deterministic non-periodic flow, which opened out that chaos exists in deterministic non-linear equations[13]. Chaos is universal phenomena in nonlinear system. Chaotic action can pass all states nonrecurring by itself rule in a certain range, so that it can gain global optimization results with high efficiency for optimal search. The basic starting point of chaotic optimization is the ergodicity, that chaotic motion can pass all states nonrecurring in a certain range. The characteristic can be effective mechanism to avoid local optimal solution and the difficulty of the continuity and differentiability of objective functions and constraints [14-19]. The idea of chaotic optimization is to transfer area coverage from chaotic series to decision variables, and then use the new chaotic variables for searching and iterative comparison. If the criterion of stop is satisfied, it exports the optimal results.

Based on the characteristics of chaotic motion, we couple the chaos theory with neural networks and propose chaotic neural networks comprehensive evaluation (CNNCE) which can conduct comprehensive evaluation of water resources allocation effects.

Water resources allocation involves many factors, such as economy, society, ecology, environment and projects, which is a multi-objective nonlinear optimal problem with

Manuscript received October 25, 2009; revised December 4, 2009 accepted January 28, 2010
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doi:10.4304/jcp.5.8.1169-1176

the characteristic of space-time variability [20]. The method takes full advantage of ergodicity of chaotic motion and the ability of neural networks to handle complex non-linear mapping. Thus, it improves the efficiency of algorithm, strengthens objectivity of the evaluate results and also has strong adaptability and replicability.

II. Chaotic Neural Network Comprehensive Evaluation Model

A. *Objective of chaotic neural network r comprehensive evaluation model*

Comprehensive evaluation by chaotic neural network is on the basis of comprehensive evaluation by neural network. Its basic idea is on the premise of complementary and finitude of local extremum between the merits and drawbacks of chaos optimization algorithms and neural network algorithms, making the two methods coupling, using the global ergodicity features of chaos optimization to achieve ergodicity and free jump in limited range of extreme for search process, achieving rapid optimal extremum of each local area by neural network algorithm, making algorithm converges to the global optimum with optimal preservation strategy. Since the three layers BP neural network, with only one hidden layer, can approach the bounded non-linear function with a approximate degree of any accuracy, therefore, generally use the three-layer BP neural network (input layer, hidden layer and output layer), without considering neurons threshold.

Comprehensive evaluation of chaotic neural network is actually an algorithm solving some optimization problem, making the following error function minimum in order to optimize the weights of neural network parameters.

$$E = \frac{1}{2}\sum_{p=1}^{P}(d_p - y_p)^2 \tag{1}$$

where E is overall error of the sample, P is the number of the sample, d_p is the desired output value of the sample, y_p is output value of chaotic neural network corresponding the sample, which can be gotten according to (2).

$$y_p = f(x, W) \tag{2}$$

where x is sample, W is the weight, $f(x,W)$ is nonlinear function described by neural networks.

B. *Chaotic neurons networks*

In biological neurons dynamics model construction history, Maculloch-Pitts neurons and Caianiello neuron are very important, the former is included in the latter. The equation is:

$$x_i(t+1) = f\left(\sum_{j=1}^{M}\sum_{r=0}^{t} w_{ij}^{(r)} x_i(t-r) - \theta_i\right) \tag{3}$$

where $x_i(t+1)$ is the output value of the neurons i in discrete time t+1; M is the sum of the input neurons, $w_{ij}^{(r)}$ ($i \neq j$) is the connection weight describing the neurons j affect neurons i activated r+1 units of time latter; $w_{ii}^{(r)}$ is the memory coefficient of neuron i affection to itself after it is activated r+1 unit time latter, θ is the right or non-activation threshold, u is unit speed function, which is defined as follows:

$$f(y) = \begin{cases} 1 & y \geq 0 \\ 0 & y < 0 \end{cases} \tag{4}$$

While construct chaotic neural network with chaotic neuron, some aspects which are different from the general neural network should be considered: feedback items from internal neuron which are similar to the Hopfield network, external input items which are similar to BP algorithm, items should not response and thresholds. Therefore, the mathematical model describing chaotic neural network is as follows:

$$x_i(t+1) = f\left[\sum_{j=1}^{M} v_{ij}\sum_{r=0}^{t} k^r A_j(t-r) + \sum_{j=1}^{N} w_{ij}\sum_{r=0}^{t} k^r h\big(x_j(t-r)\big) - \alpha\sum_{r=0}^{t} k^r g\big(x_i(t-r)\big) - \theta_i\right] \quad i = 1,2,\cdots N \tag{5}$$

Define the items affected by the function as the internal state of neuron, and then the (5) can be expressed as:

$$y_i(t+1) = ky_i(t) + \sum_{j=1}^{M} v_{ij}A_j(t) + \sum_{j=1}^{N} w_{ij}h\Big(f\big(y_j(t)\big)\Big) - \alpha g\Big(f\big(y_i(t)\big)\Big) - \theta_i(1-k) \tag{6}$$

$$x_i(t+1) = f\big(y_i(t+1)\big) \tag{7}$$

where M is the number of external input; N is the number of neurons in the network, $y_i(t+1)$ is the internal state of neuron, $x_i(t+1)$ is the output of neuron, $A_j(t)$ is external input, h is internal state feedback function, w_{ij} is weight matrix, v_{ij} is connection weight from external input, g is inadaptable function of neuron, θ_i is neuron threshold, k is refractoriness decay rate, f is internal state activity function, α self-feedback coefficient.

This model is chaotic neural network model given by Aihara. For simplicity, assume that function h and g are identity function, function f, with a steepness parameter e, is Logistic function whose external input does not change with the time. That is

$$A_j(t) = A_j \quad (8)$$

$$\sum_{j=1}^{M} v_{ij} A_j - \theta_i (1-k) = \alpha_i \quad (9)$$

$$f(x) = 1/[1+\exp(-x/\varepsilon)] \quad i = 1, 2, \cdots, N \quad (10)$$

Simplified model of chaotic neural network is:

$$y_i(t+1) = k y_i(t) + \sum_{j=1}^{N} w_{ij} x_j(t) - \alpha x_i(t) + \alpha_i \quad (11)$$

C. Chaotic learning algorithm

To take advantage of chaotic variables to achieve optimal learning, first of all should make some restrictions of BP neural network weight vector. In this paper, use Logistic map to generate chaotic variables:

$$x_{i+1} = \mu x_i (1 - x_i), \ i = 0, 1, \cdots, n \quad (12)$$

when $\mu = 4$, the system is in a chaotic state, with all the characteristics of chaos, chaos variable in (0,1) within the traverse. So it can be seen as chaotic variables iterative equation[21]. Suppose neural network has p weight parameters. Consider the following equation:

$$X_{i+1,p} = 4 X_{i,p} (1 - X_{i,p}), \quad p = 1, 2, \cdots, P, \ 0 < x_0 < 1 \quad (13)$$

$$X_{i,j}' = \sum_{p=1}^{P} (2X_{i,p} - 1)(2X_{j,p} - 1), \quad i, j = 0, 1, \cdots, n \quad (14)$$

$$\hat{W} = W^* + z_t X_{i,j}', \quad (15)$$

$$z_{t+1} = (1-\lambda) z_t, \quad 0 < \lambda < 1 \quad (16)$$

where $\hat{W}$, W^*, X_i, X_i' are all P dimension of the vector. $\lambda, z_t \in R$, W^* in (15) is approximate optimal value vector of neural network generating from (14) and by rough search; λ in (16) is attenuation factor of time-varying parameters z_t, its purpose is to realize small chaotic search in the field of approximate optimal value vector, finding global optimum of neural network weights vector.

Take any p different values from (0, 1) to substitute in type (13), get p different variables in different chaotic trajectories. Translate the variables into (-1, 1) by type (13), and then take the p chaotic locus sequence as weight coefficient solution space in coarse search of neural network, each variable of chaotic trajectory corresponds a weight parameter in neural network.

D. Steps of CNNCE model

An index system is constructed in accordance with the specific issues and then standardized. After that, CNNCE model is used for a comprehensive evaluation. The steps are as follows.

Step 1 Initialize the network and learning parameters. Setting neural network input layer, hidden layer and output layer neurons nodes N_1, N_2 and N_3, hidden layer activation function to take $g(x) = 1/(1+e^{-x})$, output layer activation function to take $g(x) = (1-e^{-x})/(1+e^{-x})$.

Step 2 Construct the training sample. Determine the neural network input values $R = [r_{p_i}]$ and expected output value $B = [b_1, b_2, \cdots, b_p]^T$. When the quantitative indicators and qualitative indicators of index system to standardized, the quantized value of evaluation index attribute values can be as the input value $X = [X_{p_i}]$. But the expected output value is generally respect the original evaluation expert experience and evaluation results, but also can use the evaluation method of multiattribute utility value theory and preference theory method to be determined. sample (R, B) can be used as the input and output values of chaotic neural network model learning samples.

Step 3 Using chaotic variables which generated by Logistic mapping, according to (11), calculated the minimum objective function value E, obtained the approximate optimal value vector $W^*\left(W^* \in R^p\right)$ of neural network weight vector, and substituted the right approximate optimal value vector W^* into (15), to obtained the network new weight vector $\hat{W} = [W_{ij}]$.

Step 4 Start chaotic neural network model to learning. Using the input mode (R, B) and the network weights W_{ij}, according the output o_{pj} of each hidden unit which computed by chaotic neural network model, and then using the output of the hidden layer o_{pj} and connection weights W_j to calculate the output o_p of the output units, and then use the network desired output d_p and the network actual output o_p , through the (11) to calculate the correction errors of output layer, and using error back-propagation of BP network, and constantly modify and adjust the right parameters.

Step 5 Learning times adds one.

Step 6 Calculate z_t according to (16), if $z_t \le Q$ (search termination conditions), then switch to step 7; otherwise, substitute the weight vector $\hat{W}$ into neural network, calculate the error function value E according to (11), and then return to step 5.

Step 7 find the minimum E^* of the objective function value E, the corresponding neural network of the right value is the global optimum value, when the network weights be determined, that means, an implicit utility function have been established between the indicator system and the utility values.

Step 8 Substitute the evaluation matrix $R = [r_{p_i}]$ which standardized by program targets as the input of utility function into the network computing, get the utility value $\left\{PV_k\right\}$ of each program, and then take this as a basis, according to the preference theory, comprehensive optimized the program, that is, corresponding to the program $PV^* = \max\left\{PV_k\right\}$ is the optimal program, at the same time, according to the utility value of each program in descending order, then obtain the relative superiority order of each program.

At the same time, because the optimization results of neural network algorithm evaluation depend on the choice of the initial value is reasonable or not in a large extent, and the results obtained by multiple running are often different, it required multiple statistical operations to get the results, but the chaotic neural network evaluation model due to the chaos optimized ergodicity, has strong stability evaluation results which be obtained. Meanwhile, the chaotic neural network evaluation model uses a multi-attribute benefit function to construct the learning samples, and to train the network, avoids the human subjectivity of the weight values determined in the traditional evaluation methods (such as the analytic hierarchy process, fuzzy comprehensive evaluation), have strong objectivity of evaluation results.

III. CNNCE ON WATER RESOURCES ALLOCATION EFFECT

A. Index system of evaluation on water resources allocation effect

The purpose of evaluation on water resources allocation effect is to choose one water resources allocation scheme which assures an efficient and reasonable allocation of water resources between each department in society. Besides, the use of water resources will satisfy sustained, stable and coordinated development of social economy and environment.

Considering the complexity of water resources allocation, there are 16 indexes to build index system of evaluation on water resources' sustainable utilization.

Available water resources(X_1):to reflect the size of the prospect for development and utilization of water resources.

Available water supply volume(X_2) :to reflect the degree of direct use of water resources for human.

Possession volume of water resources per capita(X_3):to reflect water resources' shortage degree of watershed development.

Water allocation efficiency(X_4):to reflect the ratio between water resources' total water supply and the amount of available water resources; the larger parameter indicate a higher distribution efficiency of the water resource after the optimization, and less residual water.

Industrial water recycling rate(X_5):to reflect utilization extent of water resources in industrial production cycle.

Utilization coefficient of irrigation water(X_6):to reflect supportive extent of the water resource to the agriculture productions. Duty of water is the ratio of irrigated area and cultivated land area.

Food production per capita(X_7):to reflect supportive extent of agricultural production's proportion and water to agricultural production.

Economic growth rate(X_8):to reflect the pace of economic subsystem.

The proportion of agricultural water(X_9):to reflect the level of agricultural development.

Industrial water quota(X_{10}):to reflect the level of industrial water.

GDP per capita(X_{11}):to reflect the level of watershed economic development, income and living standard.

GDP per unit of water(X_{12}):to reflect the efficiency of water utilization and the situation of industrial structure.

Guarantee rate of eco-environment water supply(X_{13}):to reflect support level of water resources to eco-environment.

Emissions(X_{14}):to reflect the pressure of socio-economic development to eco-environment.

Dilution ratio(X_{15}):to reflect the level of surface water pollution and management level of water resources.

Wastewater treatment ratio(X_{16}):to reflect the level of watershed environment protection.

Table 1 gives one watershed's quantized value of evaluation indexes for optimal allocation of water resources.

TABLE I. VALUES OF THE EVALUATION INDEXES OF WATER RESOURCES ALLOCATION EFFECT IN A CERTAIN RIVER BASIN

Index	unit	Current Year				2015				2030			
		V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
X_1	10^8m^3	15.66	15.71	15.68	15.39	16.93	16.19	16.77	16.82	16.59	16.71	16.41	16.89
X_2	10^8m^3	13.06	13.06	13.06	13.06	13.66	13.66	13.66	13.66	13.55	13.55	13.55	13.55
X_3	m^3 per capita	609.9	609.9	609.9	609.9	568.0	568.0	568.0	568.0	518.7	518.7	518.7	518.7
X_4	——	0.813	0.815	0.814	0.799	0.882	0.844	0.874	0.877	0.882	0.888	0.872	0.897
X_5	——	0.41	0.41	0.41	0.41	0.58	0.58	0.58	0.58	0.63	0.63	0.63	0.63
X_6	——	0.525	0.525	0.525	0.525	0.600	0.600	0.600	0.600	0.650	0.650	0.650	0.650
X_7	kg per capita	295.8	295.8	295.8	295.8	372.2	372.2	372.2	372.2	396.7	396.7	396.7	396.7
X_8	——	3.0	3.0	3.0	3.0	5.0	5.0	5.0	5.0	9.0	9.0	9.0	9.0
X_9	——	0.648	0.641	0.639	0.634	0.557	0.529	0.563	0.544	0.480	0.481	0.491	0.487
X_{10}	$m^3/10^4$RMB	200.0	200.0	200.0	200.0	185.0	185.0	185.0	185.0	175.0	175.0	175.0	175.0
X_{11}	RMB per capita	3754.1	3754.1	3754.1	3754.1	7036.2	7036.2	7036.2	7036.2	15155.2	15155.2	15155.2	15155.2
X_{12}	RMB / m^3	4.18	4.17	4.17	4.25	7.78	8.13	7.85	7.83	18.72	18.58	18.93	18.39
X_{13}	%	100	100	100	100	100	100	100	100	100	100	100	100
X_{14}	10^4t	14214	14563	16524	14867	16271	15867	16059	16398	19766	19584	18967	19697
X_{15}	m^3/t	7.479	7.299	6.433	7.150	6.533	6.699	6.619	6.482	5.378	5.428	5.604	5.397
X_{16}	——	0.15	0.15	0.15	0.15	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60

B. *Results of allocation effect based on CNNCE*

The index system will be standardized, using the theory of multiattribute benefit function, and we assignment the preference value as[0,0.25,0.5,0.75,1] to construct learning sample and establish CNN comprehensive evaluation model, than choose the best program by evaluation and sort the various programs. See the result at Table 2.

Similarly, by evaluating multi plan under different level years of p=50%, p=75% and p=95%, we can work out the CNNCE evaluation value and sort them, then get the best allocation scheme. For each scheme, each user's water supply from each basin can be subdivided into water resources sub-area. River's eco-environment water is deducted from total water supply, then we get various schemes under the condition of p=90% from different level years.

TABLE II. RESULTS OF THE WATER RESOURCES ALLOCATION SCHEME BASED ON CNNCE MODEL

Comprehensive evaluation	current year				2015				2030			
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
CNNCE results	0.18	0.79	0.30	0.27	0.92	0.69	0.76	0.26	0.25	0.74	0.37	0.88
Sorting	4	1	2	3	1	3	2	4	4	2	3	1
Optimal scheme	V_2				V_1				V_4			

C. *Rational analysis of results*

The entropy is often used to analyze the evolution direction of the system. As a combined system of ecological economy, the water system meets the requirements of the dissipative structure, so it is bound to comply with the evolution principle of this structure, thus the discrimination on the evolution direction of the system could be implemented through the relationship between the entropy change and the system orderliness in the dissipative structure. The concept of the entropy was initially proposed by Clausius in thermodynamics, and then an exact definition of the entropy in thermodynamics was given by Boltzmann.

$$S = K_B \log W \tag{18}$$

where S is the entropy of the system; K_B is the Boltzmann constant; W is the microstate number of the system in the macroscopic state.

Water resource system is an eco-economic complex system, it meets dissipative structure's requirement and must obey the evolution of dissipative structure, so we can distinguish the evolution direction of water resources by using the relationship between entropy change and system order. According to the definition of entropy, the entropy of water system can be defined as follows [22].

$$S(y) = k_b \log(1/PW(y)/[WPO(y)(1+i_s)^y]) \tag{17}$$

where $S(y)$ is the entropy of water system on the first y year in calculation period, k_b is scale factor, $PW(y)$ is water resources' net contribution value to national economy on the first y year in calculation period, $WPO(y)$ is water resources' potential on the first y year in calculation period.

Equation (17) quantitatively describes the relationship between water resource system's entropy, water resources' potential and the net benefits of water resources. If unit water resource potential brings higher net benefits of water resources, then the entropy of water system is smaller, this indicates higher utilization efficiency of water resources higher water saving level better overall efficiency and better situation of eco-environment maintenance.

If S(t)>S(t+1), then it represents a decrease in the entropy of the system, an increase in the degree of the order and a benign recurrent state of the system structure, thus enjoying coordinated and sustained development in the utilization of the water resources, ecological environment and in the social economy.

If S(t)<S(t+1), then it represents an increase in the entropy of the system, a decrease in the degree of the order and an unstable state of the system structure, thus a malign recurrent state taking place in the evolution of the system.

If S(t)=S(t+1), then it represents that no change happened in the entropy of the system in a certain period and the system state remained the same in these two time intervals. Generally, the system is under a steady state.

Entropy principle is used to distinguish evolution direction of water resource system for evaluation the rationality of water resources allocation effects. Because that entropy principle is to compare the size of water resources' entropy from different level years, in (17), scale factor k_b has little impact on entropy's comparison, and we use $k_b = 1$ .The net contribution value of water resources to national economy can be measured by economic objective function value of water resource allocation model, water resource potential is the summation of main stream's water resource potential and local water resource potential. Main stream's water resource potential can be calculated by main stream's runoff volume, and in local water resource potential we only consider local surface water potential because that groundwater resource potential is hard to calculate.

Through calculation, the results can be seen in Table 3.

Under p=50%, water resource system's entropy of 2005, 2015 and 2030 becomes 5.0842, 5.0002 and 4.9060 after optimization allocation, and it appears decreasing trend. By the entropy principle, the decrease of water resource system's entropy change indicates that the order degree of water resource system has been enhanced and the system is under the state of virtuous cycle, water resources are allocated rationally. The use of water resources, eco-environment and social economy are under coordinated and balanced development. Similarly, under the condition of p=75%, p=90%, p=95% and multi-average, the entropy of water resource system all appear decreasing trend which means water resources allocated rationally. All above can give the result that our research about water resources allocation is rational and logical. Therefore, the CNNCE model proposed in this paper is scientific and efficient. It has significance in enriching and developing the evaluation method of water resources allocation.

TABLE III. RESULTS OF THE ENTROPY PRINCIPLE FOR WATER RESOURCES ALLOCATION BASED ON CNNCE MODEL

Frequency	Hydrology Year	Potential ($10^8 m^3$)			Water resources' net contribution value (10^4RMB)	Entropy
		Potential of the river	Potential of local water resources	Total		
P=50%	current year	20.24	13.62	33.86	27895.00	5.0842
	2015	20.24	13.86	34.10	34088.00	5.0002
	2030	20.24	13.76	34.00	42216.00	4.9060
P=75%	current year	14.25	12.55	26.80	27919.00	4.9822
	2015	14.25	12.88	27.13	29988.00	4.9565
	2030	14.25	12.77	27.02	33374.00	4.9082
P=90%	current year	10.63	12.80	23.43	27927.00	4.9237
	2015	10.63	13.35	23.98	28903.00	4.9189
	2030	10.63	13.24	23.87	33323.00	4.8551
P=95%	current year	9.04	14.11	23.15	19544.00	5.0736
	2015	9.04	14.46	23.50	26405.00	4.9494
	2030	9.04	14.26	23.30	33123.00	4.8473

IV. CONCLUSIONS

Water allocation is an important research topic in water resources management. It is a complex system engineering related to society, economy, ecology, environment, engineering and many other factors. Now the distribution of water resources is mainly measured by economical, social and ecological objectives. For the multi-objective non-inferior solution set obtained from the optimal allocation of water, we must evaluate the allocation effects. But there are many complex factors affecting the configuration. For example, when we use Analytic Hierarchy Process method, or Fuzzy Comprehensive Evaluation, there is inevitable impact of human factors so the objectivity and comparability are poor. We attempt to apply comprehensive evaluation of the chaotic neural network model to water resources allocation evaluation. We draw some conclusions from the theoretical analysis and case studies.

First, using CNNCE model to evaluate effects of water resources can maximally overcome the impact of subjective factors. The weight of each index is obtained through training of samples. So it has the advantage of good objectivity, comparability and fairness as well as strong adaptability and replicability.

Second, it is simple in principle, convenient in calculation, accurate in results using CNNCE model to evaluate the configuration results of different years and making use of Entropy Theory in the dissipative structure to pursue rational discrimination.

Third, CNNCE model has integrated chaotic learning algorithm, so it has the feather of high training convergence speed, great search efficiency and easy to approximate the global optimal point compared with the standard ANN model.

However, as CNNCE model uses computer simulation expert to evaluate the effect of water resources allocation, thus, it requires a certain sample to train the network. Therefore, the choice of training samples has yet to be further improved

ACKNOWLEDGMENT

The authors wish to thank two post-graduates, Tianxiang GUO, Yasen ZHOU of Hohai University and Yinqin CHEN of Nanjing University of Technology for their careful review and constructive modifications. And the work is supported by Natural Science Foundation of Hohai University (No.2009422011).

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