Modeling and Planning on Urban Logistics Park Location Selection Based on the Artificial Neural Network

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***Abstract*—Nowadays China has been soaked in the craze of planning and construct urban logistics park, and almost all developed countries all regard the urban logistics park's construction as a major motivation to the national economic. It is vital that the scientific planning of urban logistics park will ensure China's rapid development. However, too many inappropriate or unscientific planning and construction under the guidance of Government have brought giant economic loss to China. How to plan and design the urban logistics park scientifically, It is a hot topic of research being widely discussed not only by Governments but also enterprisers and scholars home and abroad. This paper begins with exploratory research for modeling and planning on the urban logistics park location selection based on the BP Artificial Neural Network (BP ANN). This paper divides into 3 sections: the first to mainly introduce the history of urban logistics park development and the significance of modelling and planning urban logistics park ,the second to analyze basic principle of the BP ANN, the third to simulate and plan the location selection of urban logistics park based on the BP ANN model. The urban logistics park's location selection planning is a complicated and dynamical system engineering with a lot of black box problems, which can't be resloved by System Dynamics, Expert System and traditional mathematical methods (e.g. Operations Research, Statistics), and BP ANN model has seldom been applied to plan urban logistics park in China. So, the research in this paper is an innovation.**

***Index Terms*—urban logistics park, neural network, planning, location selection**

I. INTRODUCTION

A. The Conception of Urban Logistics Park

So far, there is not definition of urban logistics park in the Chinese dictionary of logistics terms based on national standards. Urban logistics park is regarded as the logistics base or distribution park in Japan and it is named as the Freight center in Germany. The first urban logistics park was in Tokyo of Japan in the 1960s, The term urban logistics park was first introduced by logistics expert and Professor Zhitai Wang from Japan to China[1]. Here, take the Japanese definition of urban logistics park for reference. In Japan, urban logistics park refers to the special place in the countryside or urban-rural intersections near major traffic corridors, which is created by the government from the overall interests, conforming to the logistics industry development trends. It is the logistics assembly point that makes logistics entities to be integrated in space and service functions[2].

B. The History of Urban Logistics Park Development

Developed countries attach great importance to the construction of urban logistics parks. The craze of the Japan's urban logistics park emerges in Showa 30 (1955), the Japanese have national character of easy to craze and cold, but they always keep the most enthusiasm to craze about the urban logistics parks[1]. Japanese think that the construction of the urban logistics park determines a nation's survival. In other words, whether one country can scientifically plan and build the national urban logistics park is the sign of the national level of logistics and regional comprehensive economic. This is a case, since the 1980s, Japan's urban logistics park has played a very strong growth in trade[2]. The orderly and efficient trade logistics not only enables Japanese economy to develop rapidly, but also it makes logistics industry of the country to quickly catch up with and surpass Europe, the United States and other developed countries in logistics industry.

For nearly ten years, Germany and other European countries have been in full swing to start building urban logistics park. For example, after the reunification of Germany, this country brings full-scale construction of urban logistics parks under way in the first of the 1990s[1-2]. In order to balance the country's economic development, Germany built Bremen urban logistics park that is the first real sense of urban logistics park, and takes it as the starting point, Germany's urban logistics park amounts to 33 with the rapid developing rate and created a large-scale National Logistics Network. The construction of these urban logistics parks not only has made tremendous contributions to Germany's economic balance and rapid development, but it has radiated throughout Europe and has a great impact on the entire European logistics modernization and economic development as well. In Asia, many urban logistics parks begun to emerge in Singapore, South Korea, Taiwan and other countries or regions in recent years, such as Singapore port urban logistics park, Fugu and Liangshan urban logistics park of South Korea, and Taiwan's

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Kaohsiung urban logistics park, which is currently the largest investment and scale in Southeast Asian region. The operation of these urban logistics parks has made important contributions for the international logistics and regional economic development.

C. *The Significance of Modeling and Planning Urban Logistics Parks in China*

The Craze on urban logistics parks of Chinese mainland was awakened in the 21st century. In a few short years, the Chinese Government has been aware of its great value. Under the guidance of the Chinese Central Government, almost all local governments of the country has introduced the urban logistics park planning in three years. For example, Shenzhen plans to build eight large urban logistics parks, Shanghai plans to build five major urban logistics parks, Qingdao plans to build six large urban logistics parks, and Guangzhou plans to build three major international hub urban logistics park in Nansha, Xisha and Huadu, Jiangsu province plans to build ten integrated urban logistics parks and six professional urban logistics park, etc. China enjoys the craze of constructing urban logistics park to the full, as is very heartening, but on the other hand, there are some alarming figures coming from the national statistic department. According to statistical data of the national statistic department, there are 60% of urban logistics parks which have been built at idle condition, and in this condition, there are at least 50 urban logistics parks being built or waiting to be constructed. The construction of the urban logistics park costs huge money and has a long cycle of recycling. As a result, the failure of panning and constructing urban logistics park could not really play their due role, and even become the heavy burden of the local economy, which is a very heavy lesson.

How to plan and design the urban logistics park scientifically is hot topic of research being widely discussed not only by Government but also enterprisers and scholars home and abroad. From 3rd September 2006 to 14th September 2006, Both China logistics and procurement association and Chinese economy daily publishing house hold the 6th China Logistics Expert Forum, the theme of which is how to build Logistic Park in China, but so far there is no standard, unified and accepted methods of planning Logistic Park . To plan and design these logistic parks scientifically and to take some lessons from mistakes before is an urgent task lies before the Government, scholars, and enterprisers in China.

In this paper, BP ANN is used as a modeling tool to plan the selection of logistic park location.This is an interesting and novel method to plan Logistic Park location based on BP ANN. Design and construction of Logistic Park is complicated and dynastic system engineering, which may cost plenty of money, and need a very long time to recycle funds[3]. So it's necessary to adopt scientific modeling and simulation technology with low cost before officially starting to build urban logistics park. There are two kinds of methods to design the selection of logistic park location[4]. The first is analysis method, such as qualitative analysis method, which mainly depends on government or experience of some experts, and the method is so subjective that it has brought giant economic losses in many logistic park construction; The second is quantitative analysis method, such as traditional mathematic ways like statistics or operational research. These traditional methods only can solve structure and linear problems. However, logistic park design itself exists many non-structure and non-quantity problems, which can't be solved by traditional ways[5-6]. There are also some companies in china attempt to use System dynamics modeling (SDM) to solve these problems, but the effect is not satisfacting. Compared with neuron networks, SDM is certain to build relationships among every factors in a macro views, but it can't solve unintegrated black box problems with uncertain boundary and imperfect information. Furthermore, SDM have to debug some parameters manually, and Expert System also have to input vast amount of knowledge, which must depend on if…else…then rules to output data regularly, that means Expert System only can solve white box problems. By contrast, ANN have many unique excellent performance, such as simulating human thought, parallel and distribute process, self-organized, self-taught (especially online) and self-adjust function, large memory storage, and it can solve many un-structure, semi-structure and structure problem of logistic location design, and especially it is good at solving black box problems, which can't be solved by traditional mathematic methods such as statistics, operations research and so on. Nerve networks have already be applied to many fields such as medical science, chemical industry and electric power system, but owning to its little application in logistic park location research, the research result of this paper provide a reference only.

II. BASIC PRINCIPLE OF ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) is a kind of newly emerging Artificial Intelligence (AI) technology and continues to grow in popularity within the business, scientific, and academic worlds[7-14]. With the development of modern computer and network technology, ANN has broken some of its limitation and been a main direction of today's AI research because of its high efficiency and accuracy. Simply speaking, ANN is a set of computing system to imitate the process of thinking in human brain. Its core is mathematical model and algorithm and its physically realization is based on computer software. According to the different neuron topology structure of ANN, there are currently about over 30 kinds of ANN structure. Among these kinds of ANN structure, BP ANN (Back-Propagation ANN) is the most classic one. Rumelhart raised BP ANN in 1986, for years afterwards, about 80%-90% of ANN locked to take BP ANN or its improved network, epitomizing the soul and the most perfect content of ANN[8]. Neuron topology structure, operating process and learning algorithm of BP ANN are introduced as follows.

A. *Topology Structure*

BP ANN is a kind of multi-level and feed-forward ANN. Topology structure of the improved BP ANN is

shown in Fig. 1. Seen from Fig. 1, there are three kinds of neuron layer (i.e. one Input layer, several hidden layers, one output layer) and in each level, neurons connected with the others in adjacent layers by the way of weighting. Individual nodes take the input received from connected nodes and use the weights together with neuron functions to compute output values. Notice that nodes within the same layer of the network architecture are not connected to one another.

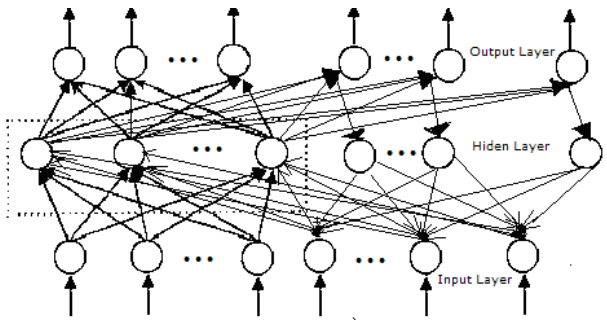

Figure 1. Topology structure of the Improved Back-Propagation Artificial Neural Network

B. Operating Phases

Operating phases of BP ANN divides into two phases. The first phase is called the learning phase and the second phase is called the computing phase.

In the first phase (seen in Fig.1), with the help of ANN's learning function, through large scale of instances, continually adjusting the weight and threshold of the network, it can make BP ANN form its own knowledge and prepare for the next stage. During the learning phase, the output for every instance is compared with the desired output. Once any error between the computed output and the desired output occurs, the error can be propagated back through the network to adjust connect-weigh values. Learning phase is terminates when error rate comes to a predetermined minimum point.

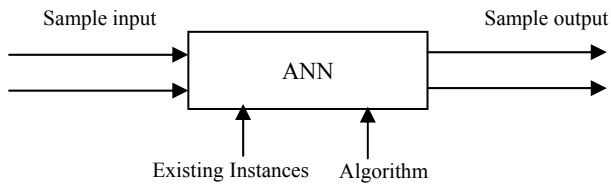

Figure 2. Learning process of Artificial Neural Network

In the second phase (seen in Fig.2), the network weights are fixed, and the network is used to compute acutual output values when there are actual inputs for new instances. Once BP ANN doesn't have new knowledge, it also has the on-line learning function.

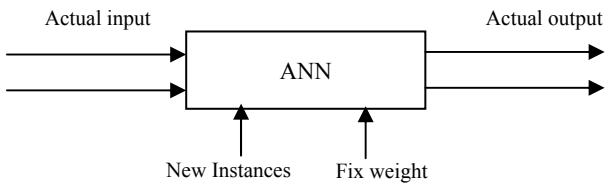

Figure 3. Computing process of Artificial Neural Network

C. Learning Algorithm

Suppose the input nodes number of the BP network is m, express vector x as equation (1).

$$x = (x_1, x_2, ..., x_n)^T \tag{1}$$

Set the number of output nodes as n, express vector y as equation (2).

$$y = (y_1, y_2, ..., y_n)^T \tag{2}$$

So, the BP ANN can be regarded as the nonlinear mapping from the m-dimensional input space to n-dimensional output space as equation (3).

$$f : R^m \to R^n, y = f(x) \tag{3}$$

Using the conduction of the transfer function, according to the principle of the gradient descends method, weight of the network can be derived as equation(4).

$$u_i(n) = \sum_{i=1}^{p} w_{j,i}(n) \times x_i(n) \tag{4}$$

If the actual output is $y_j(n)$, and the expectant output is $d_j(n)$, then the error signal is shown in equation (5).

$$e_j(n) = d_j(n) - y_j(n) \tag{5}$$

Computing actual output $y_j(n)$ is as equation (6).

$$y_j(n) = f_j(u_i(n)) \tag{6}$$

Then MSE signal is computed as equation (7).

$$\xi(n) = \frac{1}{n}\sum_{j=1}^{m} e_j^2(n) = \frac{1}{n}\sum_{j=1}^{m}(d_j(n) - y_j(n))^2 \tag{7}$$

Suppose the amendment of weight $w_{ij}(n)$ is as equation (8).

$$\Delta w_{ji}(n) = -\eta \frac{\partial \xi(n)}{\partial w_{ji}(n)} = \eta \delta_j(n) y_j(n) \quad .....(8)$$

Where, $\sigma_j(n)$ is computed as equation (9).

$$\delta_j(n) = e_j(n)\varphi'(u(n)) \tag{9}$$

So, the amendment of the weight value $w_{ij}(n)$ can also be expressed as equation (10).

$$\Delta w_{j,i}(n) = \eta \delta_j y_i(n) \tag{10}$$

Where, η is the learning step, which is used to control the speed of the adjustment, usually take: 0< η <1; $\delta_j(n)$ is the local gradient, when $\delta_j(n)=0$, the learning to stop, otherwise it continue iteration, until the overall error of the network is less than the predetermined minimum, then network converges; set the learning steps, if the number of learning steps is greater than predetermined value, and then the network training is terminated.

III. Modeling and Planning on the Location Selection of Urban Logistics Park

A. Model Design

Kolmogorov proved theoretically that any complicated nonlinearity function can be simulated and realized by a BP ANN model with three layers (input layer, hidden layer and output layer), as long as there are enough nodes in hides layer [7,11]. So, we choose BP ANN with three layers in this paper. The three layers are designed respectively as follows:

1) Designing Input Layer

According to the opinions from the famous logistics expert of USA, professor Mayor, input nodes of urban logistics park selections location are not fewer than 6. Here, we set the number of input nodes as 10 (m=10), and these key factors and the corresponding variables of the urban logistics park location selection are narrated in Table I.

TABLE I.
KEY FACTORS OF URBAN LOGISTICS PARK LOCATION SELECTION

Variable	Key factor	Variable	Key factor
x_1	Aviation	x_6	National policy
x_2	Waterway	x_7	Peripheral market
x_3	Highway	x_8	Source of goods
x_4	Land Price	x_9	Existing facilities
x_5	Environment	x_{10}	Human Resource

2) Designing Output Layer

In general, the number of neuron nodes in output layer is set as one (n=1). Output value Y of the neuron node can measure urban logistics park Location Selection. The output and error of the BP ANN are computed as equation (11).

$$y_i = f_2(x_i) = \sum_i (w_i + b_i) \cdots\cdots i = 1, 2, \cdots\cdots, 9 \qquad (11)$$

3) Designing Hidden Layer

Ascertain the number of neuron nodes in hidden layer is comparatively complicated work. On one hand, if the nodes are far from enough, the network could not be trained to get enough knowledge or can not recognize the samples with bad fault tolerability; on the other hand, if there are too many neuron nodes in hidden layer, learning time is too long, generalization capability of the network drops, and over fitting increases. Here we use two experienced equations (seen in Equation (12), Equation (13)) to get the neuron node number t of the hidden layer as 12 (t=12).

$$t \approx 1.46n - 0.46n - 2 \cdots n < m \qquad (12)$$

$$t \approx 1.46m - 0.46n - 2 \cdots m \geq n \qquad (13)$$

B. Simulation of the Neural Network Model

1) Software Environment

The thought of software developing is based on COM component, and its run environment is Windows 2000, database is SQL Server 2000, programming tool is Matlab 7, where we take the neural network toolbox 4.0 developed by Mathworks, and it almost includes all the best intelligence in AI area, completely covered the research findings of neural network. According to classical rules of modifying the network weight and the process of training the network, it could be helpful to program the sub-program for training and designing the network with Matlab. The network designer could adjust the training program based on his personal need instead of being busy with the trivial programming work.

2) Process of Simulation

ANN has two modes (namely supervised-learning mode and unsupervised-learning mode). Here we take supervised-learning mode, whose working process is as follows:

- Pretreatment: Through function premnmx() or user-defined functions to normalize the destination parameter set { y_i } and input parameter set { x_i }.
- Modeling: Use function newff() to generate the BP neural network with feed-forward loop.
- Training: Through function train() to train the first records, continually adjust the weight and threshold and make the output value have the same tendency with the expected one, so that BP ANN could get enough knowledge.
- Simulation: Through function sim() to take the last records as the actual input to simulating the actual output.
- Data treatment: Through function postmnmx() to take the non-normalize treatment to the input and destination parameters. Generally this step could be omitted.

3) Training and Calculating

There are 3000 sample records in SQL Server 2000 database, and most data come from two cities in Jiangxi province and Hainan province respectively. Network training data is 2000, training time is 333, and training step is 0.1. Limited by the length of this paper, we can only show part of them in Table II and Table III, where capitalized variables means to be standardized in the domain [0, 1].by equation (14).

$$X(i) = \frac{x_i - \min\{x_i\}}{\max\{x_i\} - \min\{x_i\}} \qquad (14)$$

When $E_{i,k}$ （calculated as Equation (15)）reaches to 0 or numerical small enough, training process is to be termined

$$E_{i,k} = \frac{1}{t}\sum_k (y_i - b_k)^2 \cdots\cdots k = 1, 2, \cdots\cdots, 14 \qquad (15)$$

TABLE II.
PARAMETERS OF URBAN LOGISTIC PARK LOCATION (1)

No	X1	X2	X3	X4	X5	Y
1	0. 986	0. 969	0. 987	0. 942	0. 954	0. 955
2	0. 878	0. 904	0. 880	0. 918	0. 867	0. 890
3	0. 839	0. 787	0. 809	0. 815	0. 764	0. 789
4	0. 684	0. 614	0. 683	0. 650	0. 622	0. 668
5	0. 528	0. 509	0. 560	0. 514	0. 539	0. 554
6	0. 461	0. 409	0. 427	0. 406	0. 430	0. 433
7	0. 308	0. 322	0. 345	0. 310	0. 318	0. 327
8	0. 290	0. 209	0. 216	0. 279	0. 248	0. 241
9	0. 986	0. 969	0. 987	0. 942	0. 954	0. 168
10	0. 878	0. 904	0. 880	0. 918	0. 867	0. 113
… …	… …	… …	… …	… …	… …	… …

TABLE III.
PARAMETERS OF URBAN LOGISTIC PARK LOCATION (2)

No	X6	X7	X8	X9	X10	Y
1	0. 975	0. 914	0. 963	0. 859	0. 874	0. 955
2	0. 916	0. 858	0. 881	0. 991	0. 875	0. 890
3	0. 779	0. 793	0. 782	0. 789	0. 808	0. 789
4	0. 653	0. 619	0. 656	0. 649	0. 683	0. 668
5	0. 581	0. 529	0. 551	0. 559	0. 560	0. 554
6	0. 448	0. 417	0. 488	0. 409	0. 418	0. 433
7	0. 309	0. 300	0. 327	0. 298	0. 319	0. 327
8	0. 245	0. 238	0. 263	0. 383	0. 276	0. 241
9	0. 159	0. 148	0. 157	0. 182	0. 196	0. 168
10	0. 093	0. 108	0. 116	0. 120	0. 098	0. 113
… …	… …	… …	… …	… …	… …	… …

IV. COMPARISON ANALYSIZING ON THE RESULT OF NETWORK TRAINING AND CALCULATING

A. *Comparison on the Network's Errors as Number of Neurons in the Hidden Layer Differs*

We can also use data in Table II and Table III for comparison and analysis. Let the number of neurons in the hidden layer of BP ANN as 10, 11, 12, 13, 14 and run the corresponding programming code, we can get network's error (seen in Table IV) after enough training time. In this table, net.trainparam.epochs is 2500 and net.trainparam.goal is 0.0001.

TABLE IV.
NETWORK'S ERRORS AS THE NUMBER OF NEURONS IN THE HIDDEN LAYER DIFFERS

Number of neurons	10	11	12	13	14
Network's errors	0.0498	0.1767	0.0413	0.1401	0.1316

As is known from Table IV, when the number of the hidden layer's neurons is 12, network's error value of the BP ANN is the lowest one. So, the number of the hidden layer's neurons of BP ANN is set as 12 in this paper.

B. *Comparison on the Network's Error as Training Function Differs*

There are 16 kinds of BP ANN's training functions in Matlab 7.0 version. Among these training functions, we select 4 kinds of training functions to train the BP ANN, and the corresponding training result is shown as Table V. From the table, we can find, when training function is trainglm(), network's error value of the BP ANN is the lowest and convergent times is the least. So, when the number of the hidden layer's neurons is 12, we choose trainglm() as training function for the BP ANN.

TABLE V.
COMPARISON ON THE BP NETWORK'S ERROR AS TRAINING FUNCTION DIFFERS

Training function	Convergent times	Network's error
trainbfg( )	122	0.6375
trainbgd( )	1585	0.1961
traingdx( )	241	0.0753
trainglm( )	60	0.04476

C. *Comparison beween Artificial Neural Network Modeling and Other Methods*

Comparison results beween BP ANN model and some other traditional mathematic methods are shown in Table VI. Mean System Errors (MSE) are calculated as equation (16), where Y' denotes evaluated value, and Y denotes test value.

$$\text{MSE}=\frac{|Y'-Y|}{Y}\times 100\% \quad (16)$$

Known from Table VI, Both MSE and time of running BP ANN model are least in the three kinds of methods, and they are 5% and 60 seconds respectively.

TABLE VI.
COMPARING BETWEEN DIFFERENT CALCULATION METHODS

Time series		Regression analysis		BP ANN	
MSE	Time	MSE	Time	MSE	Time
27%	150s	13%	89s	5%	60s

So the evaluation criteria system based on BP ANN is in reliability. Let interval changes of Y value as 0.2, 10 grades of urban logistics park location selection are shown in Table VII. In this table, the bigger ASCII value of grade is, the higher efficiency the urban logistics park location selection has.

TABLE VII.
GRADES OF URBAN LOGISTICS PARK LOCATION SELECTION

Y range	[0,0.1]	（0.1,0.2）	[0.2,0.3]
Grade	B	D	F
Y range	[0.2,0.3]	（0.3,0.4）	[0.4,0.5]
Grade	H	I	L
Y range	(0.5,0.6)	[0.6,0.7]	（0.7,0.8）
Grade	K	J	G
Y range	（0.7,0.8）	[0.8,0.9]	(0.9,1.0]
Grade	E	C	A

V. CONCLUSIONS

China is a a developing country, lots of inappropriate planning and construction have brought large loss of money, human power and material to the country. So, It is vital that scientific planning of urban logistics park will ensure China's rapid development. How to plan and design the logistic park scientifically? Currently, it is hot international topic, and it's also a controversial issue in China. Planning of urban logistics park location selection is complicated and dynamical system engineering with a lot of black box problems, which can not be resloved by ES, SDM and traditional mathematic ways such as statistics and operational research, so it is a novel, interesting, and bravery method for author to adopt BP ANN model for planning urban logistics park location selection, and the result of research in this paper is just for reference. The author hopes eagerly that China's urban logistics park planning can benefit from this research and avoid big investment venture and accelerate the development of China.

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