Research Article

Evaluation the Level of Development of Smart City Based On the SA-BPNN of PCA Method

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Abstract: With the rapid development of urbanization process, the rise of smart city has become a new direction for building the future city. However, the congestion, pollution and waste problems have being happened in various cities, which are in urgent need of a scientific evaluation system to weigh. This paper has studied a number of cities in different continents, while making a detailed analysis about the impact indicators, and through the principal component analysis to select the indicators further, so the establishment of useful output data is accomplish. Then in the construction of comprehensive evaluation system, we choose the combination of heuristic algorithm—SA and BP neural network, which can improve the speed of operation and avoid falling into the local minimum. In the 79 large and medium-sized cities we randomly calculate 2 cities, which are used to do the simulation. The results show that the predicted value and the actual value of the error there are meet the requirements, thus it proves that comprehensive model established is effective.
Keywords: smart city, comprehensive evaluation, SA-BPNN, sustainable development.

INTRODUCTION

Smart city appear with the development of the Internet, cloud computing and artificial intelligence provides an infinite possibilities for the development of big data [1,2], communication and the development of mobile devices in the convenience of life, at the same time it changes the mode of operation of the city. The challenges faced by the city is also an urgent need for new ideas, in recent years, countries have put forward the concept of the smart of the city, smart city is the depth spread of information technology and integrate applications, which is a new generation of information technology breakthrough one of the important direction and strategic emerging industries an important part of the development. IBM formally put forward the wisdom of the city vision in 2010 [3], China in 2013 released the national "smart city" technology and standard pilot cities [4], But it is currently in the initial stage, at present China has about 200 cities in the pilot construction. So many cities to actively develop, how to evaluate their level of development has become an urgent need to solve the problem.

The study of intelligent city began in the 1970s and 1980s, the first the study of intelligent building is the intelligent building, which has become the core of early intelligent city theory research [5], Yuan Jianfu in 2001 pointed out that the intelligent building complex is the future development trend [6]. Wang Zhengzhong proposed the term "intelligent building", which was associated with the information age in 2006 [7]. George Criatian Lazaroiu put forward the conceptual model of intelligent urban planning and construction [8], and had idea about evaluating the effect of intelligent urban construction planning by constructing evaluation model. Although the academic community put forward the wisdom of urban evaluation index system, but the wisdom of urban construction evaluation is not much.

Therefore, according to the present situation of the development of the smart city in China, this paper designs a set of intelligent city development potential evaluation system based on the practice and development foundation of the pilot wisdom city construction, and constructs the SA-BPNN evaluation method to evaluate the development potential of the smart city.

Basic principle

First of all, this chapter briefly describes the basic principles we use in the next because of there are many knowledge would be used by the model.

Principal component analysis

Principal component analysis is also called the main component analysis, the role is to convert multiple indicators into a few comprehensive indicators [9], to reduce the dimension of the purpose, and the principal component analysis principle can be simply stated as follows: by means of an orthogonal transformation, its component is related to the original random vector.

$$X = (x_1, x_2 \cdots x_n)^T \qquad (1)$$

Which is converted a new random variable whose component is not relevant.

$$U = (u_1, u_2 \cdots u_n)^T \qquad (2)$$

This makes it point to the sample points to spread the most open p orthogonal direction, and then multi-dimensional variable system to reduce dimension processing, so that it can be a higher precision conversion to low-dimensional variable system. As shown below, the main role of principal component analysis is to reduce the dimension, to achieve information clustering.
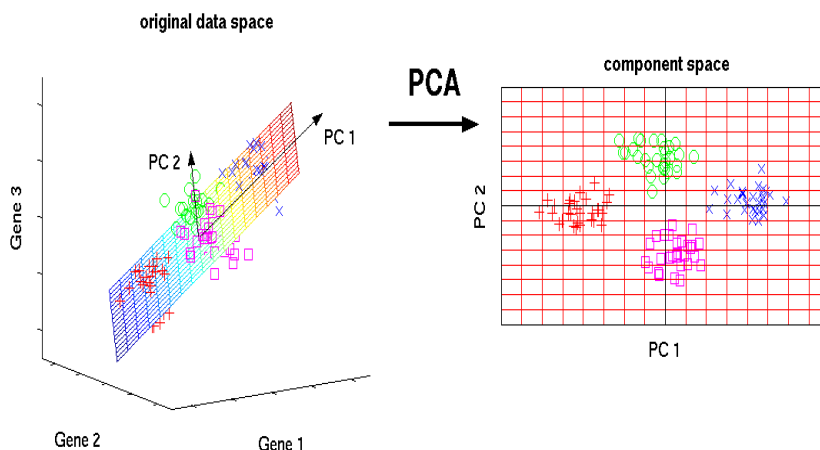

Fig.1 An example of principal component analysis

Simulated annealing algorithm

Mountain climbing method is completely greedy method, each time it choose a current optimal solution, so it can only search the local optimal value [10]. Simulated annealing is also a greedy algorithm, but its search process introduces a random factor. The simulated annealing algorithm takes a certain probability to accept a solution that would be worse than the current solution, so it is possible to jump out of the local optimal solution and achieve the global optimal solution. Taking figure 2 as an example, the simulated annealing algorithm will receive the movement of E at a certain probability after searching for the local optimal solution A. Perhaps after several times it can reach D point even is this is not the local optimal move, so it jumps out of the local maximum A.
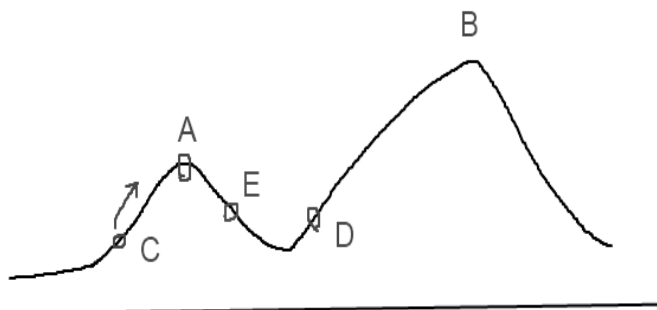

Fig.2 Process of simulated annealing algorithm

Simulated annealing algorithm description:

If $J(Y(i+1)) \geq J(Y(i))$ (it will get better after moving), the move is always accepted.

If $J(Y(i+1)) < J(Y(i))$ (the solution after the solution is worse than the current solution), then according to a certain probability of accepting the move, and this probability gradually decreases over

time (gradually reduced to stabilize). The probability is in here $p(de) = \exp(de/(kt))$, where k is a constant, $\exp$ indicates the natural index, de is poor energy ($de < 0$).

BPNN neural network

BP neural network simulates the process of brain processing information, without prior determination between the input and output mapping relationship, through the learning rules and feedback adjustment to achieve the actual output value of the network and the expected output value of the error variance is minimum. Through the following chart about its basic principles [11].
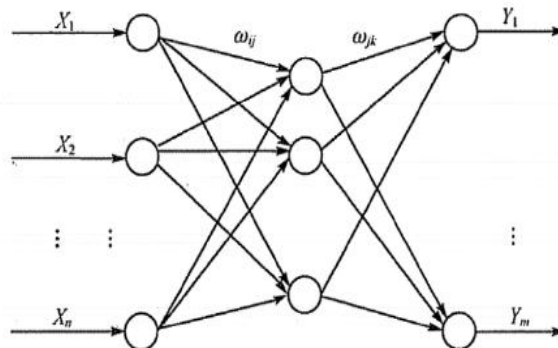

Fig.3 The Principle of BP Neural Network

From the figure we can know, $X = (X_1, X_2 \cdots X_n)$ is the input layer, ω_{ij}, ω_{jk} is the weight coefficient, a_j, b_k is the threshold of learning, Rate is η and neuron activation function is $\varphi(x)$. We choose the activation function is $\varphi(x) = \dfrac{1}{1 + e^{-x}}$.

THE EVALUATION MODEL OF BP NEURAL NETWORK BASED ON SIMULATED ANNEALING

To judge the level of a city's intelligence, the most important thing is to see the level of usage of science and technology, resource utilization, the convenience of the city, of course, we have to consider the local economic and social development level. For our comprehensive evaluation model applicability, we choose to study a number of cities, it combines with the existing research and we collected data, we initially selected variables as shown in the table below.

Table 1: 20 initial indicators

Indicator	Per thousand people have mobile equipment (min / thousand)
	The average speed of the city (M / s)
	Computer penetration (%)
	Smart home product of the shipments (min / y)
	Every thousand people have the electronic bus card (a / thousand)
	Rate of electronic bus stop (%)
	Wireless network of coverage (%)
	Number of State Key Laboratory
	Smart Grid of Coverage (%)
	Percentage of mobile payments (%)
	the computing provided power
	E-commerce transaction volume (Yuan / person)
	ICT industry share of GDP (%)
	Percentage of highly educated population (%)
	Rate of the Pollutant treatment (%)
	Applicability of e-government (%)
	Energy efficiency (Yuan / ton)
	Road congestion rate (%)
	High-tech industry investment amount (billion)
	Large data utilization (%)

(1) The choice of indicators

According to the data we get, we can find that there are problems of collinearity, excessive index and mutual interference through scatter gram. There is a correlation between the number of e-bus cards (per thousand) and the rates of electronic bus stops (%) per thousand for different cities. As shown in Figure 4 below.
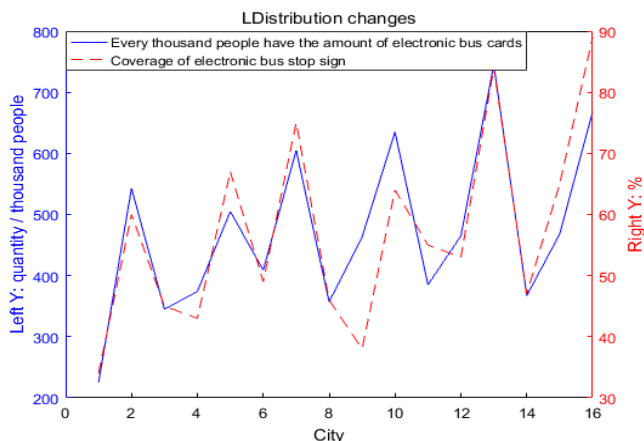

Fig.4 Variable trends and relationships between variables

In order to solve the data dimension of the disaster, the final impact of the indicators is selected according to the contribution rate of each variable and the degree of difficulty, we choose the main component analysis to reduce the dimension, and the final 20 indicators are reduced to 12 variables. As shown in the following table.

Table 2: The new indicators after the selection

Indicator	
	Per thousand people have mobile equipment (min / thousand)
	The average speed of the city (M / s)
	Smart home product of the shipments (min / y)
	Every thousand people have the electronic bus card (a / thousand)
	Wireless network of coverage (%)
	Smart Grid of Coverage (%)
	the computing provided power
	E-commerce transaction volume (yuan / person)
	Percentage of highly educated population (%)
	Rate of the Pollutant treatment (%)
	Energy efficiency (Yuan / ton)
	Large data utilization (%)

(2) Data preprocessing

Before the training, the data should be handled, the original data should be verified from the integrity and accuracy of the two aspects. For the existence of units of data is not unified, we choose to use standardized methods to eliminate dimension, we use the difference method or the mean method to complete the missing data, for obvious abnormal data, which is deleted in order to directly removal of data interference.

(3) Establish The Forecasting Model

The comprehensive evaluation model we have established is based on the training of large numbers of data. First, the data of 79 cities in 15 years are used as training samples and 12 indicators is used as input layers. The output layer is the median of the 79 cities obtained by gray correlation analysis [12]. Implicit layers are obtained from empirical formulas $\sqrt{12+1+a}$ (where $a = 3$), so there are three neurons in the hidden layer. According to the previous principle we set the error $\varepsilon = 10^{-4}$, 948 samples of data were done 5,000 iterations, 79 test samples were finalized, and results in an average error of 5.34%.

In order to speed up the training speed and accuracy, simulated annealing is introduced. It is mainly used to optimize the connection weights and thresholds. The process of simulated annealing particle swarm optimization is to find the least suitable particles according to the iterative formula. The minimum corresponding value of the fitness function represents the set of weights to minimize the variance of the sample of the neural network, and the network

converges. At this time, the optimal position and bias of the particle population represent the optimal weight and bias of the network, and the purpose of training the neural network is achieved by simulated annealing particle swarm optimization.

APPLICATION AND VERIFICATION
We analyze the situation of China's Chengdu and Dalian's smart city construction, according to the established model. We get the training structure, the variance of the two cities are obtained after data is carried out.
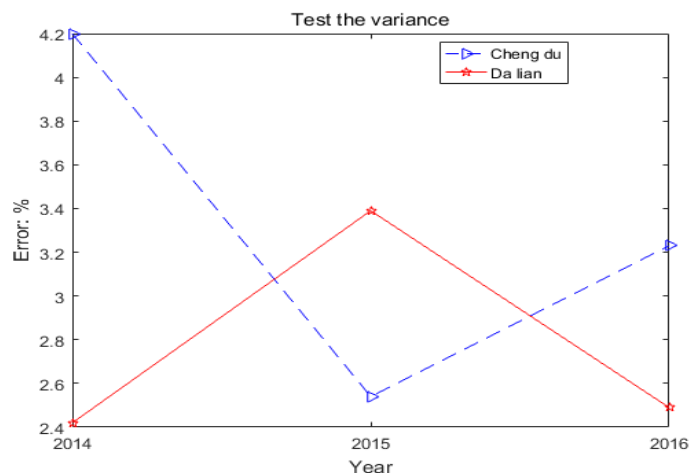

Fig-The mean square error of the training results in two groups

CONCLUSION
This article abandons the traditional mathematical modeling method, which is combined with the advantages of the computer. The comprehensive rating model of the city's intelligent level is studied based on the actual data, all this is persuasive. Through the use of BPNN algorithm, calculation cost can be saved, while cleverly using of simulated annealing robustness to overcome the neural network easy to fall into the local optimal problem.

Smart city construction of the future development is becoming the mainstream, it become the direction of our efforts whether it can effectively combine the modern scientific and technological means to optimize the urban transport, electricity and other infrastructure management, maximize the use of existing resources. The next step in our research is able to track the weak link on the basis of the assessment, so that coordinated development is useful. The applicability of the original paper also needs to be further improved, the choice of the scope of the city can be larger, and more be representative.

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