A Building Management Evaluation Method Based on BP Neural Networks

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Abstract: On the basis of in-depth study of the large number of documents, current theoretical research on overseas construction management evaluation methods is summarized. Many advanced building management theories and current models are described, as well as learnt government regulations. The study also discussed the basic building management assessment methods employed currently. On the basis of research results based on the major factors influencing construction management in the relevant literatures, a building evaluation system is built for the evaluation of a single object management architecture. The system includes: selecting the artificial neural networks comprehensive evaluation method, obtaining the sample data by questionnaire method, establishing a management evaluation model based on BP artificial neural network architecture, and applying and testing the model to evaluate the actual construction management.

Keywords: BP neural networks, construction management, evaluation methods, evaluation index system.

1. INTRODUCTION

Since the reform and opening up, China's cities have begun to develop rapidly. As of 2010, the total number of China's cities has been established as 216 cities in the beginning of reform, which have now increased to 657, an increase of more than twice. China's urban population increased from 172 million to 666 million people, so that China's urbanization rate has reached 49.68% [1, 2]. By 2015, it is expected to reach 52%, by 2030 will reach 65% and by 2050 will increase to about 75%. In the rapid progress of urbanization process, the need for large-scale construction projects and related urban infrastructure construction requires large amounts of energy and resources.

However, the current urban development promoted by the development model of China's cities is almost unsustainable. In this environment, urban building management is particularly necessary. Urban architecture development model needs to transform itself. It is the fate of the human face of economic and social development which cannot be changed. To deal with environmental issues raised by carbon emission leading to ecologically low carbon resources buildings, is an inevitable choice.

Architecture not only takes all kinds of energy, integrated vector resource consumption, but also is an important carrier of urban development. According to the World Watch Institute, building global annual production consumes 16% water, 25% of the wood and about 40% of the gravel. Construction and operation of the construction process consumes about 45% of total annual global energy demand. In the global environmental pollution in general, construction-related environmental pollution accounts for nearly 34%.

China's existing building area has more than 40 billion square meters, an annual area of approximately 18-20 million square meters. Building production requires a lot of land. In the construction and operation of the process, the direct energy consumption accounts for nearly 30% of the energy consumption of the whole society. Combined energy consumption of building materials 16.7%, accounting for 46.7% of the total energy consumption of the whole society. Water is 47% of urban water consumption, the use of steel products accounted for 30% of the country's steel consumption, cement accounted for 25% overall pollution in the environment, and construction-related air pollution, light pollution, and electromagnetic pollution accounted for 34%; and construction waste garbage accounted for 40% in total [3]. Moreover, the building has increasingly become the city's carbon emissions "big" resource. It is estimated that 60% of urban carbon emissions are from energy consumption used to maintain the building functions, while car traffic accounts for only about 30% [4].

With the continuous improvement of the rapid development of China's economy and the people's living standards, building energy in the total energy consumption with the proportion of society will inevitably increase. It is foreseeable that in the next 20 years, the building will become a major growth point of China's energy consumption. When people put forward higher requirements for building management on the urban development, human beings are adjusting their behavior and taking efforts to create new forms of economic and social development. Low carbon and eco-building based urban development model is the choice for the future development.

2. ISSUES RAISED

The grand goals of low-carbon eco-city construction and urban development have been set recently, for the urban development is bound to have a profound impact. However, the
current research on the ecology of the city and a lot of low-carbon buildings, shows that any correlations between the
two is rarely found. What is the impact of development of
low-carbon eco-city construction? Whether the synergies
between the two objectives could be achieved? Are the two
goals not completely separate? Based on these issues, this
paper discusses both the association and building of low-
carbon buildings with respect to the urban ecological mutual-
ism management system, thus find the harmonious de-
velopment of a new path for China's low-carbon eco-city con-
struction.

City's construction is inseparable from the development
of construction. Low carbon buildings is the means, the eco-
city is the goal. To promote the development of eco-cities, it
is bound to change the building's construction and manage-
ment development mode. In this context, the development of
an interactive model ecological city construction and man-
agement of research and construction of low-carbon: can
reveal the correlation of low-carbon buildings with the eco-
city and associated path from a deeper theoretical level, is
able to provide support scientific theory for the development
strategies for low-carbon eco-city and architecture construc-
tion; promote the coordinated development of eco-city con-
struction, and provides a theoretical basis for the eventual
development of eco-cities.

3. EVALUATION METHOD BASED ON ARTIFICIAL
NEURAL NETWORK AND ITS ADVANTAGES

Artificial neural network is composed of a large number
of simple information units called neurons in a complex
network of connections, and is widely used to simulate the
human brain structure and behavior of the network. Its work-
ing principle is based on the sample data provided, by a net-
work of learning and training, to identify the intrinsic link
between input and output, and thus strike problem solution
[5].

Evaluation method based on artificial neural network is
defined by the neural network learning and training, estab-
lishes the method of comprehensive evaluation model, which
is closer to human thinking patterns and combines qualitative
and quantitative analyses [4]. Building management evaluation
solves problems, compared with the use of traditional evalua-
tion methods, such as AHP, fuzzy theory analysis and
other evaluation methods based on artificial neural networks,
and thus has significant advantages.

First, evaluating the building management is a very com-
plex problem, a variety of factors influence each other, and
there is a complex nonlinear relationship. Artificial neural
network model of a typical sample of neural network learn-
ing, has a self-learning, self-organizing, adaptive ability and
strong advantages of fault tolerance. Trained neural network
experts assess by thinking the right way to create a network
connection fully reflecting the nonlinear relationship be-
 tween indicators, that can accurately simulate experts as-
sessed work, reducing the workload of the expert assess-
ment, shortening the evaluation cycle, to avoid the impact of
human factors and fuzzy randomness in the evaluation pro-
cess [6, 7].

Second, the current building management theory and its
evaluation is not yet mature. Practice is also still in the de-
velopment stage. There are some differences between different
ideas and expert evaluation criteria. How to evaluate the
raw data obtained from various experts in the scientific
treatment, excluding the impact of which individual data
elements, expert evaluation to learn the essence of thought,
is a major difficulty of carrying out construction manage-
ment evaluation. The artificial neural network model has a
strong fault-tolerance capability to deal with those noisy or
incomplete data, with the generalization capabilities, pro-
vides a powerful tool to solve this problem. In addition, the
artificial neural network model has a strong self-learning
ability. By learning new sample, the knowledge of the net-
work can give more scientific and accurate evaluation re-
results. Thus, the evaluation model has a good growth conduc-
tive to the rapid development of construction management
and evaluation research.

4. ECO-CITY AND CONSTRUCTION MANA-
GEMENT ASSOCIATION ANALYSIS

4.1. Build Self-Organizing Structure of Ecosystems

Collaborative is a science which researches the rules and
characteristics of the system transiting from disorder to or-
der. The so-called collaborative, coordinated system means
many subsystems, cooperation or joint action synchroniza-
tion, which is the intrinsic performance of the system integri-
ty and the correlation [5]. Eco-city and building manage-
ment is the ecosystem of two subsystems; the presence of both
gives a sense of competition between them, which results in
a non-harmonious, non-equilibrium state. The cooperative is
uniting the movement tendency of some two subsystems
such as non-equilibrium conditions between them, to reach a
state of equilibrium, so that the whole ecosystem is the or-
derly development of the state.

In the construction management, three important param-
eters dominating the evolution of two subsystems i.e. the low-
carbon city and the eco-city, are the fast variable, order pa-
rameters and control parameters. Fast variable system had no
effect on the entire process of structural change; the order
parameter always affect whole process of system evolution,
the decision the structure and function of system evolution;
Control variable is a role of the external environment on the
system, or an incentive [6].

To more complex ecosystems of the two subsystems of
low-carbon cities and construction management, its differen-
tial equations group is as follows:

$$p = r_j p_j - f_j (p_1, p_2, \ldots, p_n), j = 1, 2, \ldots, n$$

(1)

Where: $p$ is the system state; $p_j$ indicates the state vari-
ables, including program variables and fast variables; $r_j$
is the damping coefficient.

To simplify the calculations, "adiabatic elimination method" can be used to reduce the fast variable sequences.
When the system is in a critical state, it is possible to quickly
form an ordered structure. Other external factors has little
effect, that is the affect of the internal system parameters
changes quickly when the system is not large. Therefore, the
order parameter can be considered to represent all parameter changes. This can order parameter equation with a few approximate expression system running, so as to form a self-organizing structure. This approach is called the "adiabatic elimination".

Self-organized structure, low carbon cities and construction management of the two systems interact, for collaborative development. We built a self-organizing structure, according to the specific path of interaction with low-carbon eco-city urban environment as well as external control between the quantitative descriptions of the ecosystem, to find the coordinated development of the two subsystems.

(1) From the point of ecological system

\[ p = r_j f_0(t) - f(t) \]  

(2) From the viewpoint of the subsystem

Moreover, we analyzed the interaction between two subsystems, urban and low-carbon eco-city, and their respective variables. Assuming X is the internal force generated by one of the subsystems variable, which represents the force generated of self-interest building subsystem; Y represents another subsystem, the force that acts on self-protection subsystem of the eco-city, produced by X, because they have control action. The equations of motion subsystems can be expressed as follows:

\[ X = -r_1 \cdot X - x \cdot X \cdot Y \]  

\[ Y = -r_2 \cdot Y + y \cdot X \cdot X \]  

In the above formula, \( r_1 \) and \( r_2 \) represent the damping coefficients, which are constant. When X eliminates, subsystem Y is in a stable state. Since Y shows the presence of damping, under the damping effect X gradually restores to the state of \( Y = 0 \). This also explains that the parameter \( r_1 \) is far greater than 0. Now suppose that \( r_1 \) is much smaller than \( r_2 \), and let \( Y = 0 \), then solve the equation \( 0 = -r_2 \cdot Y + y \cdot X \cdot X \), you can get [8, 9]:

\[ Y(t) = \frac{y \cdot A^2}{r_2} \]  

Correspondingly, the variable Y is also counterproductive in the order parameter X, which by coupling relationship with the order parameter Y, influences and restricts the formation of order parameter and its role. Substitute the formula (7) into (8):

\[ X = -r_1 \cdot X - x \cdot X \cdot Y \]  

The result obtained is [10]:

\[ X = -r_1 \cdot X - \frac{x \cdot y \cdot A^3}{r_2} \]  

In this formula, the variable Y is completely replaced by the order parameter X. We got one evolution equation only containing orderly parameters. Since the whole system is controlled by the order parameter, then the evolution equation will represent the evolution equation of the entire system. On the other hand, with the changes of external conditions, the order parameter X occurs in similar systems evolutions.

Considering the state of the system for different values of \( r_1 \), when \( r_1 \) is much larger than 0, this time evolution equation has only one stable solution, which is \( X = 0 \), that is, the system will be in a steady state when \( X = 0 \).

5. BUILDING MANAGEMENT EVALUATION MODEL BASED ON BP ARTIFICIAL NEURAL NETWORK

5.1. The Basic Principle of BP Artificial Neural Network Model

Here, the use of the BP neural network model with multi-input and single-output as a building management evaluation, gives the following topology as shown in Fig. (1) and Table 1.
A Building Management Evaluation Method Based on BP Neural Networks

The three layers of BP neural network topology.

Non-linear relationship between the output and input of each node is described as Sigmoid function, that is:

\[ f(x) = \frac{1}{1 + e^{-x}} \]  

(10)

BP neural network learning and training is a background propagation and correction process [11,12]. The total error is defined as samples of actual output and the desired output function is:

\[ E_{total} = \frac{1}{2} \sum_{j=1}^{n} (b_j - b_j')^2 \]  

(11)

Table 1. Architecture evaluation index system.

<table>
<thead>
<tr>
<th>Target</th>
<th>One Level Index</th>
<th>Two Level Index</th>
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<td>Management Normative</td>
<td>Management Organization I11</td>
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<td>Reduce energy consumption I27</td>
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</table>

5.2. Obtained Data

As there are much qualitative factors in the evaluation, so the expert judgment method was used. Highest score is 10 points; the lowest score is 1 point. Then, the expert scoring method for building management was used to make a comprehensive evaluation to obtain their evaluation scores. Using the above method, the organization of 18 experts in Wuhan artificial construction management assessed the credibility of the authority to obtain higher evaluation results (Table 2).

5.3. Implementation of Algorithm Model and the Result

The steps of construction management evaluation model algorithm based on BP artificial neural network are as follows:

1. Determine the structural parameters of BP network, namely number of nodes in each layer of neurons.
2. Use MATLAB to establish an artificial neural network, and select the training function;
3. Input data, start learning and training network. By constantly performing iterative process to meet the learning accuracy.

As can be seen from Figs. (2 and 3), with the increase of the number of iterations, the expectation and variance are gradually converged (the iteration times is 20). And the final expectation converges to 5, the variance converges to 4. On the other hand, the performance of inputting 18 records is better than the performance of inputting 10 records, which converges faster.
CONCLUSION

On the basis of in-depth study based on the large number of documents, current theoretical research of overseas construction management evaluation methods is summarized. Many advanced building management theories and current models are described, as well as learnt government regulations. The study also discussed the basic building management assessment methods employed currently. On the basis of research results based on the major factors influencing construction management in the relevant literatures, a building evaluation system is built for the evaluation of a single object management architecture. The system includes: selecting the artificial neural networks comprehensive evaluation method, obtaining the sample data by questionnaire method, establishing a management evaluation model based on BP artificial neural network architecture, and applying and testing the model to evaluate the actual construction management.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

Table 2. The indicator assessment data result.

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