Ekoloji 28(108): 587-592 (2019)

LETTER TO THE EDITOR

Environmental Assessment Model of Green Ecological Residential Buildings Based on Bayesian Network

Dongmei Li[1], Dehua Jia[2*]

[1]College of Landscape Architecture and Arts, Northwest A&F University, Yangling 712100, China

[2]College of Horticulture and Gardening, Yangtze University, Jingzhou 434025, China

[*]Email: x_gz99@163.com

Aiming at the problems of low accuracy and long time-consuming in the existing green ecological residential building environment assessment model, a green ecological residential building environment assessment model based on Bayesian network is proposed. Based on the analysis of the four basic characteristics of green ecological residential buildings, the environmental assessment model of green ecological residential buildings is constructed by using Bayesian network. The concrete implementation steps include structure learning, parameter learning and reasoning calculation. For structure learning, expert construction is used to determine the Bayesian network node, and then construct causal topology structure, including initial network and transfer network. For parameter learning, EM algorithm is used to train and learn discrete data sets to obtain the probability distribution of different nodes. The BN with known structure and parameters is reasoned and predicted, and given test data sets, the probability distribution of different nodes is obtained. The probabilistic distributions of different time nodes are used to obtain the environmental assessment results of green ecological residential buildings. The experimental results show that the evaluation accuracy of the model is high and the time-consuming is low, which indicates that the model is feasible.

Bayesian Network; Green Ecological Housing; Building Environment; Assessment Model

1 Introduction

Modern urban residents have a new change and development in their living concept. Attention to the health of their homes has raised people's living consciousness and living level to a new level. Various eco-green houses, waterscape houses and noble residential districts that meet the requirements of people's homes have emerged as the times require. The design of residential buildings is facing a green ecological revolution. Although there is no unified standard definition for green ecological residential buildings, it should include the following meanings: firstly, combining the local natural ecological environment to arrange the relationship between the organization of buildings and other relevant factors rationally, so that residential buildings and the environment become an organic combination; secondly, it has good indoor climate conditions and strong ability to adjust the biological climate to meet the comfortable environment for people's work and life. It can form a virtuous circle between people and buildings and natural environment to achieve sustainable development in the future. In the spirit of architecture, it should reflect not only the epoch, but also the history and human environment of the region. Researchers in related fields have studied it and achieved some research results:

In 2019, Youn-jien Lin, Han-yi Chen, Wen-bor Lu published an article in the Journal of Ekoloji (Issue 107)

entitled “A DEA-based Study on the Environmental Performance Assessments of Urban Land Use”. The purpose of the research is to create many environmental problems based on the important role of cities in global environmental change and large-scale over-exploitation and construction. As people become more aware of the importance of environmental protection and sustainable development, humans cannot ignore the impact of environmental changes on society and the ecological environment. Therefore, a DEA-based urban ecological land development performance evaluation model is proposed. (Sujatha et al., 2017)This article uses the Delphi method and data envelopment analysis method. The decision-making unit is 21 cities in Guangdong Province. The data in the annual reports issued by these cities are used as input and output of the evaluation indicators in this study. Based on the empirical results of DEA, this article aims to provide a reference for improving the environmental performance assessment of urban land use planning. According to the analysis results, only one of the 21 DMUs has strong morphological efficiency, indicating that the efficiency is better than other DMUs. The efficiency scores of the seven DMUs are between 1 and 0.9, and the efficiency scores of the remaining 13 DMUs are lower than 0.9. Through sensitivity analysis, it identifies the key influencing factors of urban land use development, and makes recommendations based on the analysis results, in order to help reduce the environmental impacts of urban land use planning through better evaluation beforehand. Although this article mentions the assessment of the green eco-residential environment, it has not been studied in depth.

Yun, Su and Yu proposed a factor analysis model based on factor analysis for environmental assessment of healthy residential buildings. Aiming at the problem of residential health which has been paid more and more attention in residential construction at present, this paper uses factor analysis method of multivariate statistics to establish data model from physical and social environment of residential area through actual survey data, analyses various factors affecting residential health and evaluation points under these factors from three levels, and preliminarily obtains the physics that mainly affects residential health.(Sarma et al., 2017) Factors and social factors have realized the validation of the evaluation index system structure of residential health impact. However, this method has the problem of inaccurate evaluation. Yang et al presents a risk assessment model for indoor environmental health of residential buildings based on stochastic theory. Based on the deterministic risk assessment model, the model parameters are optimized and improved, and a residential health risk assessment model based on stochastic theory is proposed. The model fully considers the uncertainties in the evaluation process. Monte Carlo simulation and electronic sampling algorithm are used to calculate the uncertainty residential health risk assessment model with multi-parameters in the new method. The calculation results show that the model can overcome the shortcomings of the traditional single-value point risk assessment and make the indoor health risk assessment more practical. However, this method is too complex and it takes a long time to evaluate.

Aiming at the problem of low accuracy and long time-consuming of existing methods, a green ecological residential building environment assessment model based on Bayesian network is proposed.

2 Idea Description

2.1Analysis of basic characteristics of green ecological residential buildings

The purpose of environmental assessment is to select feasible technology and cost of platform to create the best impact on the environment in residential buildings. Environmental assessment establishes objectives and standards to enable developers, contractors and owners to further understand the living environment. We should fully recognize the harmful effects of buildings on the environment, enhance the awareness of global warming, acid rain and ozone layer destruction caused by buildings, and reduce the abuse of non-renewable resources, such as water and wood. Environmental assessment can also reduce regional environmental pollution, improve the treatment of

construction waste and increase the recycling of waste (Banani et al. 2016). Environmental assessment plays an important role in improving indoor environment and living comfort.

The environment of green ecological residential buildings should have clean air, water and soil, not be harmed by unhealthy natural environment, and not vulnerable to natural disasters. The basic characteristics are as follows:

(1) Buildings should try their best to maintain and open up green space, plant trees around buildings to prevent wind and shade, improve the landscape and maintain ecological balance. Pay attention to indoor air quality and keep fresh air flowing in the room. Valuable ancient cultural or architectural sites near buildings should be preserved and properly resettled (Ondova and Estokova 2016).

(2) Minimum consumption of resources, energy and other resources of buildings. Buildings should make full and effective use of water, energy, materials and other resources. Make the best use of clean energy (such as geothermal and solar energy, water energy, biological energy and wind energy) to protect and improve the natural environment. It can reduce consumption and save resources while satisfying people's health, comfort and safe use.

(3) Buildings should have reasonable orientation layout to make full use of solar energy. In order to reduce the energy consumption of heating and refrigeration, the shape coefficient of buildings should be reduced. The envelope structure of buildings should adopt high efficiency thermal insulation structure, and have good natural ventilation system and sufficient natural ventilation conditions. The rooms in buildings should be set up and arranged appropriately, which not only meets the comfort of use, but also saves energy.

(4) Recycling and reusing resources. Building materials dismantled from old buildings, such as masonry, steel, wood, planks and glass, should be recycled according to different situations, so as to achieve a good cycle of building materials – building - building materials - new buildings. It also actively uses other industrial and agricultural waste materials and uses advanced technology to reduce the cost of building operation and management. The old buildings should not be demolished as far as possible when the structural conditions permit. They should be reformed to adapt to the new use functions and save the construction cost. Therefore, the modern green ecological residential building is an effective use of resources and energy, environmental protection, friendly to nature, comfortable, healthy and safe building, which is a "sustainable development" building.

2.2Environmental assessment of green ecological residence based on Bayesian network

The evaluation of residential building environment involves all aspects of residential developer, design, construction, owner and property management, which runs through all stages of planning, design, construction and use. The government should give guidance and adopt laws and regulations to restrict it. Environmental assessment considers not only residential buildings in use, but also environmental impacts in construction. It emphasizes that assessment should be given in design.

Bayesian network can combine prior knowledge with sample data, dependency and probability representation. It is an ideal model for data mining and uncertain knowledge representation. It has important applications in intelligent systems dealing with uncertain information, which has been successfully used in medical diagnosis, statistical decision-making, expert systems and other fields (Zhao and Wang 2016). Applying it to the environmental assessment of green ecological housing, this paper proposes a green ecological residential building environment assessment model based on Bayesian network. The specific implementation steps mainly include three steps: structural learning, parameter learning and reasoning calculation. For structural learning, the method of expert construction is used to first determine the Bayesian network nodes, and then construct the causal topology, including the initial network and the transfer network. For parameter learning, the EM algorithm is used to train the discrete data sets to learn different nodes. By reasoning and predicting BN with known structure and parameters, given the test data set, the probabilistic distribution of nodes in different time can be obtained.

2.2.1Structural learning

The directed arc is constructed to determine the network node variables, the dependence relationship between the initial nodes and the dependence relationship between the adjacent nodes.

(1) Selection of node variables. The selection of network nodes is to determine the evaluation index of natural environment of green ecological residential buildings. The natural environment is a green ecological residential environmental form composed of geographical environment, vegetation coverage, hydrological conditions and other natural factors; building energy consumption, human history constitute a green ecological residential environmental social form.

(2) Construction of initial network and transfer network. From the above analysis, the state assessment of green ecological residential building environment is mainly considered from two aspects: physical factors and social factors.

2.2.2Parameter learning

The structure of Bayesian network is constructed. The next step is to learn the parameters, that is, to determine the conditional probability distribution, and to use EM algorithm to learn the parameters, so as to find the maximum likelihood estimation of the parameters.

(1) Data processing and state determination. Because Bayesian networks deal with discrete data, it is necessary to discretize the element data to determine the node state value.

(2) Conditional probability distribution learning. First, the probability distribution of each node is initialized, including the prior probability, the observation probability and the transition probability. Then, according to the reasoning mechanism and the given training data set, the EM algorithm is used to learn the parameters. That is, the initial conditional probability distribution is iteratively modified to obtain the most consistent probability distribution with the objective training data.

2.2.3Inference computation

Network reasoning is to update the status of network nodes according to the current or future information changes, and use the causal relationship between nodes to update and transmit information. Finally, the state distribution of target nodes is inferred, and the evaluation results of the environmental status of green ecological residential buildings are obtained.

Firstly, the joint tree reasoning mechanism is constructed by 2.2.2. Then the evidence data is input and the probability distribution of the target node is obtained by reasoning and prediction. The data of physical and social elements are discretized and input as network evidence, i.e. the discrete values of observation node variables are input, and the output values are the evaluation results of reasoning prediction for the environmental state of green ecological residential buildings.

Through the above steps, the green ecological residential building environment assessment model based on Bayesian network is built.

3 Results

In order to verify the practicability and superiority of the proposed Bayesian network-based green ecological residential building environment assessment model, a simulation experiment was carried out. The running platform was MATLAB simulation software and the operating system was Windows 10. By comparing the designed model with the model proposed by Yun, Su and Yu (2016), the experimental results are as follows:

Firstly, the accuracy of the two models is compared, and the comparison experiment is shown in Figure 1.

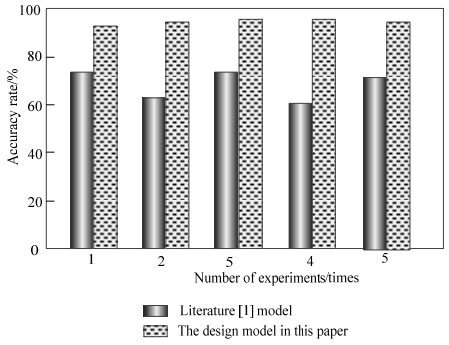

Figure 1 Accuracy comparison results

Analysis of the above figure shows that the accuracy of the article of Yun, Su and Yu (2016) modelfluctuates between 60% and 75%, indicating that the accuracy and instability of the model is low. The accuracy of the designed modelin this study is above 95%, and the fluctuation is relatively stable, indicating that the accuracy of the evaluation model is high and stable. By comparing the two methods, the performance of the designed model is better.

In order to further verify the superiority of the designed model, the time consumption of the two methods is compared. The experimental results show that the evaluation time of the designed model is much lower than that proposed by Yun, Su and Yu (2016), the comprehensive practicability of the designed model is verified again.

4 Discussion

In the experimental part, the evaluation accuracy and evaluation time of the designed model are compared with the model in article written by Yun, Su and Yu (2016). The comprehensive comparison of the two aspects shows that the designed model has higher evaluation accuracy and more time-consuming evaluation. The main reason is that the designed model uses Bayesian network to construct a green ecological residential building environment assessment model. The learning method is to select network nodes based on expert knowledge, construct network topology structure, and then learn the network from objective data through intelligent learning algorithm. Because the variable causality of the natural ecological network modeling of the green ecological residential building environment is obvious, this method can effectively combine the subjective and objective knowledge and improve the evaluation efficiency.

5 Conclusion

Aiming at the problems of low accuracy and long time-consuming in existing methods, a green ecological residential building environment assessment model based on Bayesian network is proposed. The experimental results verify the comprehensive practicability of the model. As ecological architecture is a new thing, the way of research and exploration in the future will be long and arduous. With the advance of industrial age to information age, the transformation of machine civilization to ecological civilization and sustainable development will gradually become the main theme of the century. The development of ecological building theory will lead to the great development of architectural science and technology content and the corresponding development of architectural art creation.

References

Banani R, Vahdati MM, Shahrestani M, et al. (2016). The development of building assessment criteria framework for sustainable non-residential buildings in Saudi Arabia. Sustainable Cities & Society 26:289-305.

Lin, Y., Chen, H., & Lu, W. (2019). A DEA-based Study on the Environmental Performance Assessments of

Urban Land Use. Ekoloji 28: 1513-1519.

Ondova M, Estokova A. (2016). Environmental impact assessment of building foundation in masonry family houses related to the total used building materials. Environmental Progress & Sustainable Energy 35(4):1113-1120.

Sarma, S. S. S., Garcia-Garcia, G., Nandini, S., & Saucedo-Campos, A. D. (2017). Effects of Anti-Diabetic Pharmaceuticals to Non-Target Species in Freshwater Ecosystems: A Review. Journal of Environmental Biology 38(6SI): 1249-1254.

Sujatha, S., Venkatesan, G., & Sivarethinamohan, R. (2017). Principal Determinants of Toxicity Reduction by De-Oiled Soya Using Multivariate Statistics: Principal Component Analysis and Multiple Linear Regression Analysis. Applied Ecology and Environmental Research 15(3): 1717-1737.

Yang KL, Zhang HZ, Zhang ZG, et al. (2016). Localization Study of Environmental Health Risk Assessment Model for Lead Exposure. China Population Resources and Environment 26(2):163-169

Yun Z, Su WJ, Yu CC. (2016). Application of Factor Analysis In Healthy Housing Environment Evaluating. Journal of Beijing Technology and Business University (Natural Science Edition) 26(4):42-45.

Zhao X, Wang J. (2016). Suitability Evaluation for Residential Construction and Its Land Allocation Based on Ecological Niche Suitability Model. Journal of Computational & Theoretical Nanoscience 13(4):2370-2375.