

## LETTER TO THE EDITOR

## Simulated Optimization of Building Environment for the Elderly in Severe Cold Area

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China has formally entered an aging society, and the living environment and quality of the elderly have attracted wide attention. In order to optimize the building environment for the elderly in cold areas, starting with the interpretation of the material and energy transfer connotation of building envelope structure, the limitations of the existing methods of environmental parameter analysis under reductionism are analyzed, and the analysis methods based on the integral information of the building environment in cold areas are presented exploratory research. The application of information fusion technology to describe the outdoor comprehensive environmental information shows that the neural network method is more suitable for the study of building environmental information analysis method, and a framework of building environmental information fusion system based on the neural network method is proposed. Finally, the corresponding relationship between building envelope structure and filter structure is established by analogy analysis. Based on the idea of filtering algorithm, the way of describing the filtering effect of building envelope structure on outdoor environmental information is clarified, which provides a theoretical reference for future research on indoor environmental response characteristics under the comprehensive influence of environmental information.

Building environmental information; Material energy transfer; Information processing; Information fusion; Filtering theory

### 1 INTRODUCTION

The traditional thought of “harmony between man and nature” and architectural culture in China emphasize that the process of building should “advocate heaven and earth” and “moderate moderation”, and that the way of building should aim at providing people with good physiological and psychological information. Landscape architecture, which integrates the living environment with the natural environment, enables people in the prosperous areas to appreciate the atmosphere of the natural environment, which is the concrete embodiment of this construction idea. Environmental information integrates many known or unknown parameter information. It acts on buildings and people with material and energy as carriers (Gulersoy and Celik 2017). It is characterized by complexity. Based on reductionism, modern science restores this environmental information to some basic physical parameters, such as temperature, relative humidity, solar radiation, wind speed, wind direction, etc. Through the analysis of each parameter, it cognizes the characteristics of natural environment, and analyzes the material and energy transfer process of building envelope structure under the action of single parameter (Gao et

al. 2017). In fact, the research based on reductionism neglects the interdependence between the parameters and the integrity of the building environment. Therefore, the recognition of the natural environment will inevitably lead to certain deviations, and relevant scholars have done research on this.

Nurul Azita Salleh, Kamal Ab Hamid, Mohd Nasrun Mohd Nawawi, Suzana Abd. Mutalib published an article in the journal of Ekoloji on Issue 107 in 2019, entitled “Improving Safety Culture: Positive Environmental Impacts of Information Delivery to Foreign Workers” (Salleh et al. 2019). This literature study improves the safety culture through training courses to reduce the damage caused by foreign workers in the dangerous environment of the construction industry. Its focus is on developing a framework for the need to provide information to foreign workers based on misunderstandings in health, safety and environmental induction training (HSEIT). The quantitative method is convenient for sampling. The respondents are foreign workers engaged in construction work in the natural environment. They receive training on how to protect themselves from dangerous environments and ecological events. In general, the demand framework can have a huge impact and contribution to the construction industry, in which it can serve as a guide and alternative reference for all aspects, such as course instructors, security commissioners and the construction and development commission (CIDB). In fact, in addition to facilitating teacher content delivery in training courses and eliminating language barriers in HSEIT, the environmental framework can increase the information and understanding gained to meet the needs of foreign workers working in natural settings. This may also help CIDB achieve the course objectives, improve safety performance in an open environment and the safety awareness of foreign workers.

In order to optimize the simulation of the old building environment in cold areas, this paper puts forward the following two considerations: how to synthetically represent the building environment information? How to describe the process of forming indoor environmental information through material and energy transfer of envelope structure under the comprehensive influence of outdoor environmental information? This research is based on the limitations of the environmental parameter analysis method for reductionism, and turns to explore the building environmental information analysis method (Tian et al. 2017). Applying information fusion technology and filtering theory, this paper explores and studies the description method of comprehensive characterization parameters of building environment information and the “filtering effect” of building envelope structure on outdoor environmental information.

## 2 IDEA DESCRIPTION

The information of natural environment in cold areas is transferred from outdoor to indoor through the filtering function of building envelope structure (Zhang et al. 2017). American chemist Onzag has done a lot of research on the energy transfer process of matter. The results show that the transfer process depends on the combination of direct transfer effect and additional transfer phenomenon (Zhao and Wang 2018). If there are multiple transfer driving forces  $X_i$  ( $i = 1, 2, \dots, n$ ) in the system at the same time, the effect of material and energy flow  $I_i$  produced by them will affect each other. The relationship between the flow vectors can be described by the linear equation system (1).

$$I_1 = L_{11}X_1 + L_{12}X_2 + L_{13}X_3 + L_{14}X_4$$

$$I_2 = L_{21}X_1 + L_{22}X_2 + L_{23}X_3 + L_{24}X_4$$

$$I_3 = L_{31}X_1 + L_{32}X_2 + L_{33}X_3 + L_{34}X_4$$

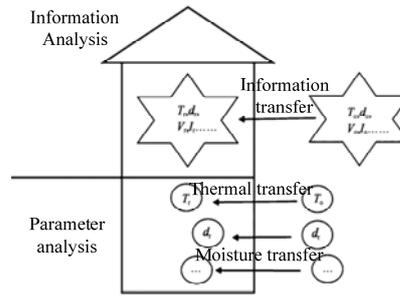
$$I_4 = L_{41}X_1 + L_{42}X_2 + L_{43}X_3 + L_{44}X_4 \tag{1}$$

That is to say, the essence of material and energy transmission through enclosure structure is the overall transmission process of building environment information, which is described as a complex problem. Limited to the level of science and technology, scholars at home and abroad have made a lot of research on heat and moisture transfer of enclosure junction based on reductionism and parameter analysis method, mainly including model research method and system identification method (Yin 2017). The main problems of the model research methods are as follows:

- (1) the mechanism of material-energy coupling transfer in enclosure structure is complex, and the existing research is not deep enough to accurately model and solve the multi-parameter coupling effect;
- (2) there are some limitations in the application of the existing mathematical model theory, such as the assumption of constant coefficients or physical meaning are unclear;
- (3) because of the imperfection of the theory, the simulation results must be verified with the measured data in order to ensure the reliability of the results.

The system identification method avoids the above problems to some extent (Wang et al. 2018). Based on modern control theory, the dynamic thermal characteristic model of envelope structure is established. It does not need to know the structure of envelope structure and the complex mechanism of material and energy transfer. It only needs to measure the input and output data of envelope structure system. The parameters response characteristics of indoor environment can be predicted by using certain data processing methods and system identification algorithm, and the thermal characteristic model of envelope structure can be calculated (Zhang 2017). Compared with traditional identification methods such as least square method, spectral analysis method and frequency domain regression method, neural network algorithm and filtering algorithm have the advantages of simple calculation and high accuracy, so they are widely used.

In summary, the analysis method of material and energy transfer parameters has achieved some results, but its essence is reductionism method, which decomposes the whole environmental information transfer process into local or low-level things to study, that is, to study the coupling effect of a parameter or a finite number of parameters, which is more difficult to truly reflect the comprehensive process of building environmental information. Building environmental information analysis method is based on the integrity of building environmental information. By establishing the fusion relationship between environmental parameters, the comprehensive effect of building environmental information is considered as a whole, so as to realize the transformation from environmental parameter analysis to environmental information analysis method. Figure 1 shows a schematic diagram describing the energy transfer process of enclosure structure material by using information analysis method and parameter analysis method respectively.



**Figure 1 Different analysis ideas of energy flow process of enclosure structure material**

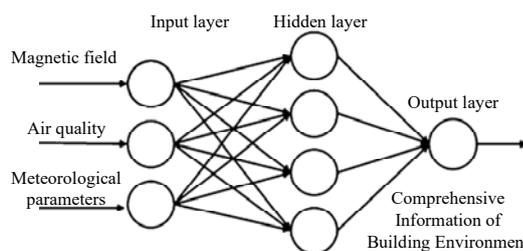
As can be seen from Figure 1, the information analysis method embodies the integration of holistic and reductionist analysis methods. On the one hand, the natural environment information can not be simply decomposed into parameters. On the other hand, the existing achievements of reductionist analysis method and the integration of measurable environmental parameters are expected to be used. Therefore, in a sense, it reflects the way of applying the integrated method of complex problems in the field of building environment.

### 3 RESULTS

Referring to the system identification method applied in reductionism analysis, this paper attempts to apply the multi-source information fusion technology and filtering theory to the analysis of building environment, fusing the environmental parameters collected by temperature, relative humidity and illumination sensors under certain conditions, so as to achieve the purpose of synthetically characterizing the building environment information, and analogizing the input and output signals of the filter to the building. Based on the information of indoor and outdoor environment, the corresponding relationship between envelope structure and filter is established, and the "filtering effect" of building envelope structure on outdoor environment information is described by referring to the signal processing process of filter.

#### 3.1 Information Fusion Technology for Comprehensive Representation of Building Environment Information

Information fusion technology is an information processing process that uses computer technology to analyze, synthesize and dominate the multi-sensor observation information acquired in time sequence under specified criteria, and to complete the required decision-making and estimation tasks. This technology provides a way to fuse the information of building environmental parameters and obtain comprehensive information representing the whole environment. Building environment information sources are complex, and there are complex non-linear relationships among the parameters. In the process of information fusion analysis of building environment parameters, the use of neural network fusion algorithm has great advantages. Artificial neural network fusion algorithm is a theoretical mathematical model of human brain neural network, which can carry out complex logic operations and non-linear relations. Its topological structure is shown in Figure 2.



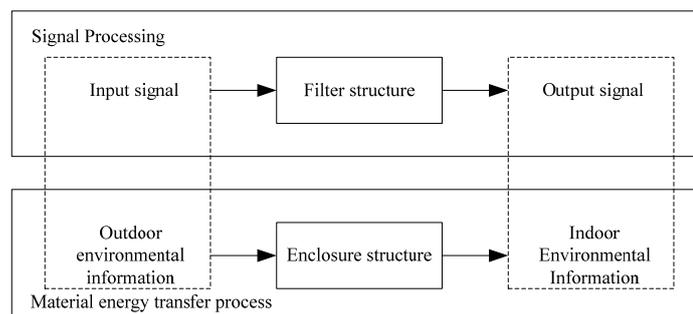
**Figure 2 Topological structure of neural network**

Firstly, the uncertain reasoning mechanism is obtained through specific learning algorithm using the information of building environment parameters (such as magnetic field, air quality, meteorological parameters) collected by sensors, and the comprehensive information of building environment is output. Then, information fusion and re-learning are carried out continuously according to this reasoning mechanism.

History data fusion process: firstly, eigenvalues are extracted from observation data of building environment parameters. These features can be divided into two groups, one is time-related (i.e., the eigenvalues change with time), such as extracting the eigenvalues of temperature, relative humidity, solar radiation and other parameters from meteorological data; the other is space-related (the eigenvalues change with location). Then, based on the neural network algorithm, the extracted eigenvalues are fused, and the relationship model between the comprehensive information of building environment and the information of environmental parameters in time and space is established to synthetically represent the information of building environment.

### 3.2 Description of the Filtering Effect of Envelope Structure on Outdoor Environmental Information based on Filtering Theory

The basic principle of filtering is to filter the input signal containing clutter and change the spectrum characteristics of the signal to get the desired output signal. The envelope structure has the same effect on the transmission of outdoor environmental information, such as attenuating the parameters of temperature and humidity, and insulating the light information by opaque envelope structure. That is to say, the envelope structure can "filter" the outdoor comprehensive environmental information. As shown in Figure 3, an analogy method can be used to describe the filtering effect of envelope structure on outdoor environmental information.



**Figure 3** Signal processing and material energy transfer processes

Based on the theory of filtering, this study takes the outdoor environmental information as input signal and the indoor environmental information as output signal, and describes the "filtering" effect of envelope structure on environmental information by the method of filter processing input signal. This filtering effect can be used to simulate and optimize the environment of building for the elderly in cold areas.

## 4 DISCUSSION

In order to simulate and optimize the environment of building for the elderly in cold area, a filter system is designed to satisfy these indexes based on given the input and output signal indices. The problem of filtering process research is as follows: 1. Given the indoor and outdoor environment information, the characteristic parameters of the corresponding envelope structure can be obtained; 2. Given the system characteristics and input signals, the output of the system in time or frequency domain can be obtained, and the signal can be analyzed. Material and energy transfer process research issue is as: 1. Given indoor and outdoor environmental information, the corresponding envelope structural characteristic parameters can be obtained; 2. The outdoor environmental information and the characteristic parameters of the envelope structure are known, and the indoor environmental information is predicted.

## 5 VCONCLUSION

By discussing the way of changing parameter analysis method to information analysis method, this paper realizes the simulation and optimization of the environment of building for the elderly in the cold area, and draws the following preliminary conclusions:

1. Information fusion technology of communication theory provides a way to synthetically characterize the characteristics of building environment information.

Based on the filtering theory, the signal processing process of the filter and the information transmission process of the building envelope can be analogously analyzed.

In this paper, the preliminary exploration results are described theoretically, and the approach of building environment information analysis is put forward. On this basis, combined with the measured data, the proposed framework of neural network information fusion system is applied to fuse the information of environmental parameters, so as to obtain the specific description of the comprehensive characterization parameters, which provides a basis for the further optimization design of the environment of the elderly buildings in severe cold areas.

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