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Public Building BIM Safety Early Warning Algorithm Based on Improved Cyclic Wavelet Neural Network

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***Abstract*—This paper uses an improved cyclic wavelet neural network algorithm to predict the safety of public buildings in BIM. First, by introducing the BIM safety warning model, the feasibility of the BIM model in the safety warning of public buildings is analyzed. Then, this paper proposes an improved cyclic wavelet neural network training algorithm, which composes the parameters of the wavelet neural network into a multi-dimensional vector, which is used as the particles in the algorithm to evolve. The BIM module extracts 4M1E basic factor information, combines the cyclic wavelet neural network algorithm to establish a safety prediction model, and adjusts the unsafe behavior and equipment in the BIM model through the prediction results. The prediction results show that the algorithm can effectively predict the safety problems of public buildings**

Keywords— BIM, Security Warning Algorithm, Cyclic Wavelet Neural Network, Early warning simulation

I. INTRODUCTION

Evacuation behavior in large public buildings is not only essential for safety in emergency situations, but also an important part of daily safety management. How to quickly, orderly, and safely complete the evacuation of people from all areas of the building is a problem that must be strictly considered in building design and operation and maintenance management. Traditional evacuation simulation relies on complicated parameter settings, such as total evacuation time and channel carrying capacity, which are based on empirical formulas; the existing commercial software uses numerical simulation, which has greatly enhanced scientificity, but there are still complex modeling and dynamic decision-making calculations. Issues with huge volume and weak visualization capabilities. In order to improve the evacuation response ability of public buildings and provide good visualization functions, a public building safety early warning algorithm based on BIM and machine learning is proposed [1-5].

At present, most of the relevant calculation specifications for the number of employees in the building were formulated in the 1980s. Nowadays, it is more accurate by studying the escape process of evacuees with obstacles, evacuation test exercises, and numerical simulations of various evacuation software. Taking into account the density of people in the building, the influence of individual differences, age levels, psychological factors, gender, and the familiarity of the test individual with the environment on the evacuation speed are considered in more detail. To prove that the number of staff in the building calculated by the specification does not match the actual situation. This shows that traditional calculation methods are no longer suitable for the increasingly complex calculation of building capacity at this stage [6-11].

At present, the research of BIM in the operation and maintenance phase, including public safety management, is still in its infancy. In recent years, related research has shown a trend of rapid growth. BIM has become more and more widely accepted in construction engineering, and it has brought many benefits. The BIM platform has strong data integration and sharing capabilities and visual expression capabilities. It has stored information about the personnel activity space (the nature of the room, the shape and area, the carrying capacity of personnel, etc.) and the components related to emergency evacuation (such as doors, floor-to-ceiling windows, walkways, etc.). Basic information of stairs, etc.). Through the extended attribute mechanism of BIM, the evacuation model information defined in this study can be fully integrated, and then the calculation model can be automatically derived using spatial relationships [12-15].

Machine learning is an important part of artificial intelligence (AI), involving various computer technologies such as mathematical modeling, optimization algorithms, and computer software and hardware. Its purpose is to enable computers to acquire new knowledge through human-like learning behaviors and to improve their performance in specific fields. A chess game can be used as an analogy. The evacuation strategy in a specific situation is a game of chess with a game record. "Evacuation strategy set" is equal to "distribution of evacuation situation in the building" + "complete evacuation route corresponding to personnel"; the best strategy for personnel at the intersection of each node is equivalent to the best move in the game [16]. This research will use a variety of machine learning technologies as the core of the dynamic strategy device to complete the decision-making of interaction with the real-time environment during the evacuation process. At the same time, explore the data integration and expression capabilities of the BIM platform, improve collaboration performance in the pre-processing and post-processing stages of evacuation countermeasure calculations, simplify the workload and make the calculation results easy to understand and apply. Finally, the dynamic decision-making calculation and display of the evacuation behavior of people in large public buildings are realized. Combined with data mining (DM) technology, the results of the evacuation simulation platform are post-processed, and a large number of data sets are cooperatively analyzed to obtain valuable information about safety management [17-20].

In 2002, the American Autodesk company integrated and summarized the virtual building concept proposed by the Hungary Graphsoft company and the Signal Building Information concept proposed by the American Benetly company to launch the Revit software. The first in our country that came into contact with BIM technology was that some architectural design institutes learned about the concept of BIM technology through Revit software. And Shih-Hsu et al. established a four-dimensional evacuation BIM model based on BIM technology, taking a building in Taiwan as an example. The four dimensions are evacuation evaluation, planned evacuation routes, safety education, and equipment maintenance. But he only qualitatively calculated the safe evacuation time and measured the farthest distance to the evacuation exit [21-24].

II. The Proposed Methodology

A. BIM Security Warning Algorithm

BIM (Build Information Model) is the abbreviation for "Building Information Model". In the 1970s, the American professor Charles Eastman proposed the architectural description system in his published articles. The American National BIM standard defines: "BIM is a digital expression of the physical and functional characteristics of a facility; BIM is a shared knowledge resource, a means to share information about this facility, and to make all decisions in the life cycle of the facility from concept to dismantling. The process of providing a reliable basis; at different stages of the project, different stakeholders insert, extract, update and modify information in the BIM to support and reflect the collaborative work of their respective responsibilities"

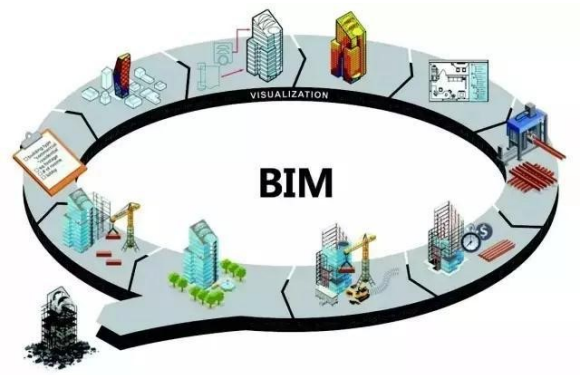

Fig. 1. BIM in the life cycle of building safety

BIM is a scientific application technology for the life cycle of a construction project that has emerged in the construction industry with the rapid advancement of modern science and technology. It has changed the situation of inaccurate expression in plan drawings and complicated and difficult drawings. BIM technology is the second revolution in the construction industry. From CAD and other 2D drawing to the current realization of BIM3D, BIM4D, and BIM5D, the accuracy of drawing has been greatly improved, the production cost has been reduced, the productivity of the construction industry has been improved, and the material waste in construction has been reduced. BIM has a powerful information processing function, it can participate in the entire project from the initial stage to the final project operation, so BIM shows a process rather than a result. BIM is to express the different needs of the project in different periods and different situations through the mutual sharing of data between a variety of different information technology software platforms, that is, it is often said that BIM has multiple functions. The I in BIM is information, which is the information stored in the BIM model. As a shared digital information resource, the digital information of these buildings can be extracted and used by related platforms at different stages of the project.

B. Cyclic Wavelet Neural Network

Cyclic wavelet neural network, referred to as wavelet network. It is based on the rapid development of wavelet analysis. In recent years, a feed-forward neural network has been newly developed. It combines the self-learning ability of neural networks with the good time-frequency localization properties of wavelet analysis. Pattern classification, fault tolerance and function approximation capabilities, etc.

The model of cyclic wavelet neural network is shown below.

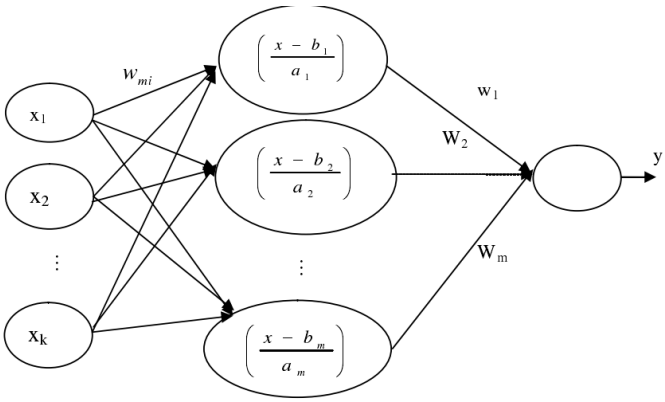

Fig. 2. Cyclic wavelet neural network model

Wavelet neural network was first proposed in 1992 by Dr. Qginghua Zhan, who is very famous in France, and it has become an emerging method in mathematical modeling analysis methods. Its basic idea is: neurons are replaced by wavelet elements, and the Sigmoid function of the neural network is replaced by a scale function or wavelet function as the excitation function of the wavelet neural network. It combines the independent learning ability of traditional neural networks with the good time-frequency localization properties of wavelet transform, and can divide various forms of wavelet networks into two categories according to their structure: one is called "loose wavelet neural network", which refers to They are both closely connected and independent of each other. The second type is called "compact wavelet neural network".

$$hi_m^n = \sum_{i=1}^{k} w_{mi} x_n(i) \tag{1}$$

$$ho_m^n = \sum_{j=1}^{l} w_{mo} x_n(i) \tag{2}$$

Loose wavelet neural network means that the results obtained after wavelet analysis and processing are used as the input data of the neural network, and then the self-learning ability of the neural network is used for training, and the weights and attributes of the network are modified to achieve the identification, processing and extraction of useful information. Purpose: The hidden node function of the compact wavelet neural network is replaced by the expansion and translation parameters of the wavelet basis function. It still uses the learning and training method of the BP network to realize the mutual penetration and organic integration of wavelet analysis and neural network.

C. BIM Technology Applied to Safety Prediction

The three-dimensional visualization model established by BIM technology can restore the buildings in reality 1:1. Provide the required evacuation building environment for personnel evacuation simulation software. Compared with the evacuation environment provided by the previous evacuation software modeling, it is more intuitive and real. The BIM model stores the detailed information of all the structures of the building, which can be used at any time to retrieve the detailed information of the structure of the building, and the model can be rotated, scaled, layered and roamed as needed. Applying the BIM model to the evacuation software makes the buildings in the evacuation simulation environment closer to the real situation, and an accurate evacuation simulation plan can be obtained.

$$y_n^p = f_n^p(x) \tag{3}$$

$$I_p^n = \sum_{N} w_{nk} O_k^p \tag{4}$$

The BIM model contains all the information of the building structure, but the entire BIM model of the building requires a lot of storage space. Processing all the information of the entire BIM model requires a higher-configured computer processor. Generally, a computer cannot process a BIM model that is too large at one time. The main improvement of BIM for the safety evacuation simulation software is that the structure and part of the building can be converted into the data information of the evacuation simulation software. However, the current evacuation model cannot be directly imported into the BIM software. This step also needs to be developed through the secondary editing of computer language. Zhao Yiding realized this process through secondary development, but still did not solve the problem of excessive storage of BIM information and inconvenient operation.

III. EXPERIMENT

Using MIB technology, the figure of the public building safety factor is shown below.

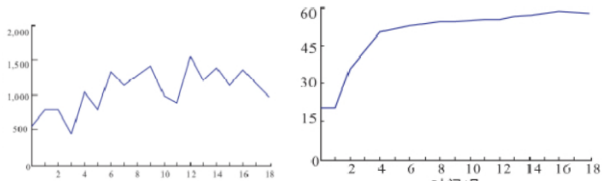

Fig. 3. Public building safety factor

Take the actual running process of the case study as an example, the self-learning algorithm has executed multiple iterations, and a total of eight generations of strategy networks have been trained from the first to the eighth generation (No. 1-8). The figure of training method is shown below.

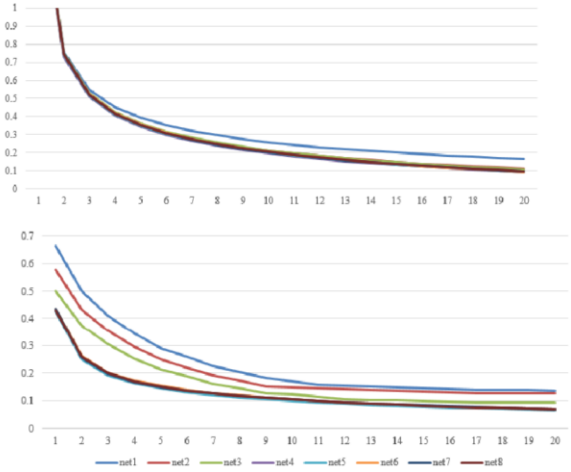

Fig. 3. Model training method

The result of BIM applied to the safety prediction of the building is shown below.

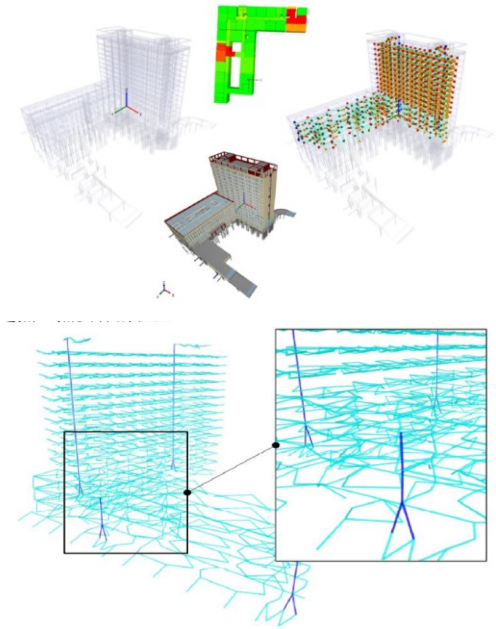

Fig. 4. similarity measure of auditory tensions

IV. CONCLUSION

Aiming at the public building safety problem, this paper adopts the algorithm based on improved cyclic wavelet neural network to make BIM prediction. The 4M1E basic factor information is extracted through the BIM module, and the cyclic wavelet neural network algorithm is used to establish a safety prediction model, and the unsafe behavior and equipment in the BIM model are adjusted through the prediction results. The prediction results show that the algorithm can effectively predict the safety problems of public buildings

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