2024 International Conference on Telecommunications and Power Electronics (TELEPE) | 979-8-3503-6921-2/24/$31.00 ©2024 IEEE | DOI: 10.1109/TELEPE64216.2024.00011

Research on the Prediction Model of Green Building Carbon Emission Based on Computer Big Data

Zheng Yufeng[1,a], Li Jiaxuan[2,b], Wang Sijie[3,c], Ying Danlei[4,d,*], Chew Boon Cheong[5,e]
[1]Taizhou Vocational and Technical College, Haizhou City, Zhejiang Province, China
[2]Taizhou Vocational and Technical College, Taizhou City, Zhejiang Province, China
[3]Taizhou Vocational and Technical College, Jinhua City, Zhejiang Province, China
[4]Taizhou Vocational and Technical College, Taizhou, Zhejiang, 318001, China
[5]Universiti Teknikal Malaysia Melak, Durian Tunggal, 76100, Malaysia
[a]1960083261@qq.com, [b]304822369@qq.com, [c]3241019370@qq.com, [d]yingdanlei@tzvtc.edu.cn, [e]bcchew@utem.edu.my
*Conespongding author

***Abstract*—A prototype system for predicting building carbon emissions based on Revit was developed. Then the validity of the proposed algorithm and the established information model is tested. The carbon footprint of the building is estimated to assist in the development of the design plan. This reduces the carbon dioxide emissions of the design plan. The system is divided into four modules: wall performance setting module, hot area utilization information module, energy consumption prediction information screening module and statistical results module. Secondly, the function and interaction of each module are discussed in detail. Construction of carbon emissions from urban buildings - a forecast model for reducing emissions. NSGA-II multi-objective genetic algorithm is applied to the conventional. The BP neural network is modeled and solved. The model is trend of urban buildings under the double targets of carbon emission and carbon reduction.**

Keywords—Building carbon emission, building information model, building carbon reduction, BP neural network, nsga-ii multi-objective genetic algorithm

I. INTRODUCTION

The construction sector is the country's largest source of carbon dioxide emissions. In view of the situation of high energy consumption, low resource utilization rate and high environmental pressure in China's construction industry, the life cycle assessment theory is applied to the construction industry. Measured by carbon dioxide emissions. Some scholars have established a set of energy consumption evaluation model based on life cycle to realize the quantitative evaluation of energy consumption and environmental impact [1]. This reduces CO_2 emissions over the life of the building. In view of the main problems, some scholars have predicted of building design schemes in the whole life cycle based on energy conservation and emission reduction goals. The early-stage building carbon emission forecasting technology is studied [2]. By developing a building carbon emission prediction prototype system for the initial stage of design, this study verified the feasibility of existing methods and information models, and realized the prediction of building carbon emission for the initial stage of design, thereby supporting design decisions and reducing the carbon emission of design schemes.

II. DESIGN OF CARBON EMISSION MANAGEMENT SYSTEM IN THE PHYSICAL AND CHEMICAL STAGE OF BUILDINGS

A. System Working Principles

In the process of building materialization, each participant obtains the relevant data of construction project progress and carbon emission through the BIM platform, and uses the access layer to control the project progress, cost, safety and carbon emission. In order to effectively implement the coordinated management of carbon emission in the material process, the scope and limit of the carbon emission system in the material stage of the material process must be clearly defined [3]. The unified code of carbon emission information of material process is constructed, and its information is classified and stored, so as to achieve the purpose of storage and quick reading in the engineering process. Secondly, it studies the data integration, sharing and transformation of each participant in the process of construction project materialization, and establishes the process of construction project materialization based on BIM. People realize the transmission, sharing and collaborative management of carbon emission information among different participants.

B. Building Information Model and Related Theories of "Cloud"

Cloud technology requires service automation and network access convenience, which can efficiently gather resources at all stages of the construction project, integrate all stages, professions and participants in the construction process into a "cloud" technology platform, and use the "cloud" terminal to query, modify, delete, store and annotate, so as to build a collaborative working mode for participants [4]. Using the advantages of BIM in the "cloud", information asymmetry is reduced and inaccuracy is reduced. In the process of building materialization, based on the cloud. (Figure 1 is quoted in Collaboration and BIM model maturity to produce green buildings as an example) organizational strategy). A carbon emission control system for the construction entity phase was established (Figure 2 is cited in Sustainability 2023, 15(18), 13648).

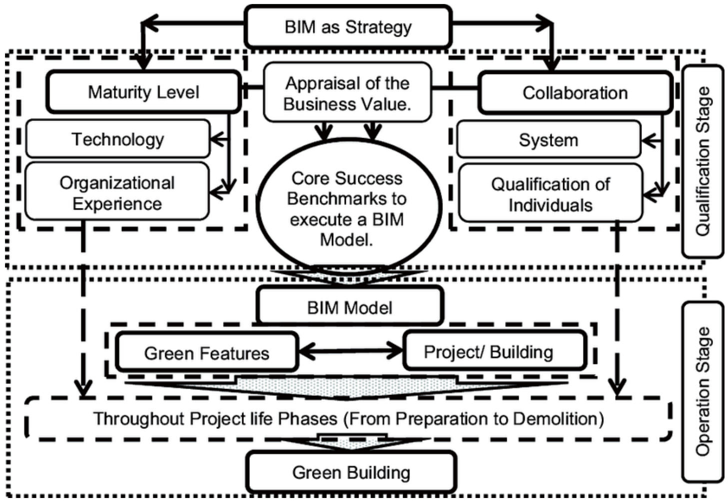

Fig. 1. BIM and "cloud" technologies work together to manage organizational relationships

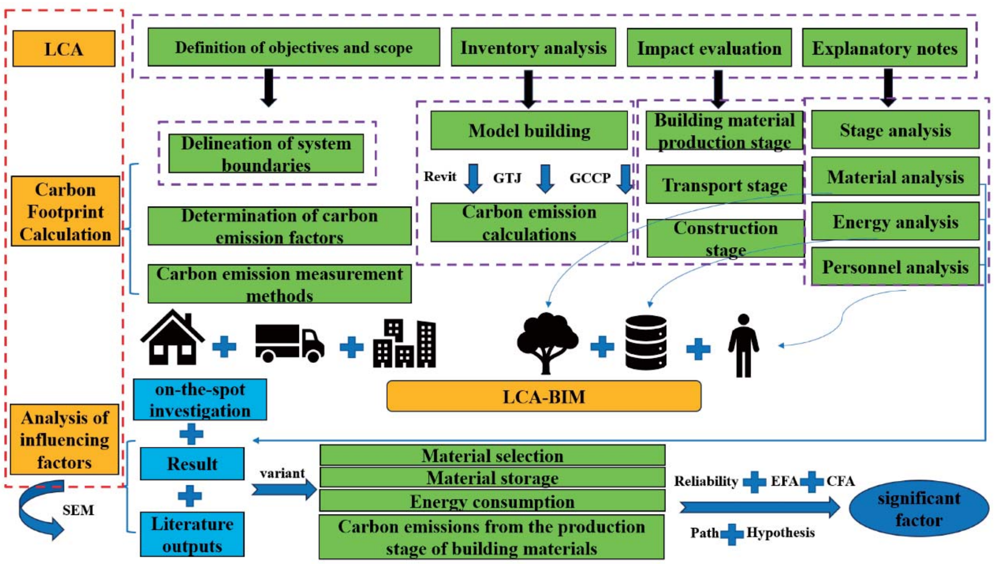

Fig. 2. Carbon emission management system architecture based on BIM technology in the physical phase of construction projects

1) Data Layer

The BIM collaborative management system can be divided into BIM information and external information, and it is constantly updated. The data of BIM model includes the physical attributes, geometric attributes and management attributes of components, including the composition, function and behavior of products and other related attributes [5]. External information includes multiple sources of information, such as progress information, cost information, safety information, carbon emission information, etc. Optimize, classify and integrate BIM data and other data in the process of construction project materialization. This is easy to query and use.

2) Access Layer

Its responsibility is to connect with the database, through the data access AIDS and SQL database to achieve the relevant data operation commands from the business logic layer, complete the data reading, query, delete, translate and add and other work, and feedback the completion of the data to the business logic layer.

3) Application Layer

According to the needs of carbon emission management in the process of construction project materialization, it is divided into three aspects: schedule management, cost management, carbon emission management and safety management [6]. Raw materials are selected according to the cost, schedule and carbon emission management of construction projects. The corresponding sub-construction process is formulated, so as to achieve multiple functions of carbon emission management in the material period of construction projects.

4) Interface Layer

The platform is based on the Internet and cloud computing, and realizes the interaction with end users, and realizes the management of different user rights. In the process of materialization of the construction project, all participants log in as users and obtain the corresponding identity verification. Query, input, modify and comment according to their respective permissions.

C. System Process

The operating process of the prototype system for building carbon emission prediction is shown in Figure 3(the picture is quoted in Buildings 2023, 13(1), 205). The system consists of four modules: wall performance setting module, hot area utilization information module, energy consumption prediction information screening module and statistical results module [7]. Through reading and transforming engineering modeling data in Revit, project management is realized. The database of the system was established by using CeData_Coe, and the prediction of the utilization parameters of hot zone, material property parameters and carbon emission coefficient was realized.

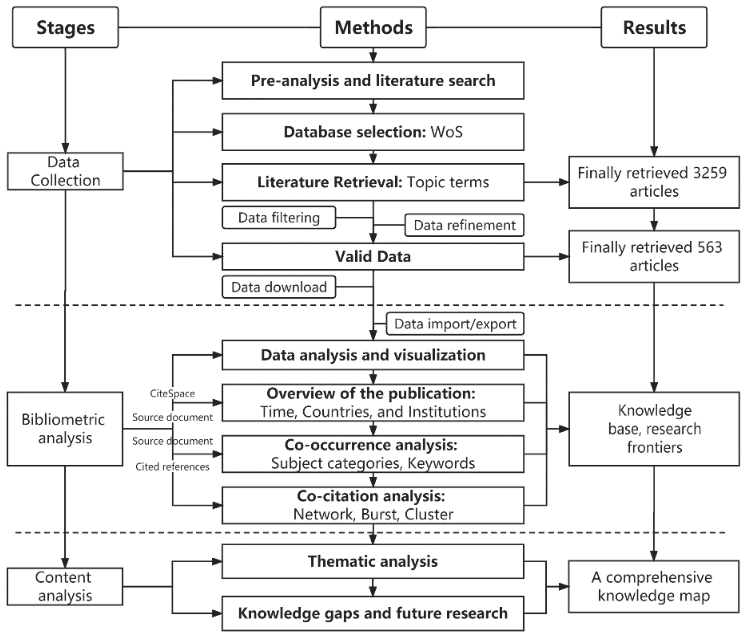

Fig. 3. Operation flow chart of the prototype system for building carbon emission prediction

III. NSGA-II IMPROVED BP NEURAL NETWORK WAS USED TO FORECAST CARBON EMISSIONS OF BUILDINGS

The BP neural network improves the convergence of the algorithm and ensures the diversity of sampling points through the optimal preservation strategy. NSGA-II is a multi-target gene algorithm with high convergence, which can give complex parameters according to the degree of crowding between people[8]. The BP neural network operation process is as follows:

A. Determine the Weights and Thresholds of the BP Neural Network

A set of initial weights and thresholds with the size of K are randomly generated as parental populations Ft and Dt , and genetic operations (selection, crossover, and variation) are performed on the parental population code to produce progeny populations Gt and Vt , and Ft is combined with Gt, Dt and Vt to produce populations Kt and Yt with the size of 2K. The non-inferior classification operation was carried out for the populations Kt and Yt, that is, the non-dominant sorting was carried out according to the non-inferior solution level of the individuals, and the crowding distance of the individuals of the same rank was calculated respectively [9]. The individuals with the highest domination height and the largest crowding distance were selected to enter $Ft+1$ and $Dt+1$ until the scale reached N . Crowding distance of individual i :

$$F[i]_{dis\tan ce} = F[i+1]\cdot h_1 - F[i-1]\cdot h_1 + F[i+1]\cdot h_2 - F[i-1]\cdot h_2$$

Where $F[i]_{dis\tan ce}$ is the aggregation distance of individual i , and $F[i]\cdot h$ is the function value of individual B on multiple objectives.

The Kt and Yt individuals are substituted into the model, and according to n output values compared with the expected value, the genetic algorithm ends when the error is within the required range.

B. BP Neural Network Model

The initial by NSGA-Ⅱ genetic algorithm and tested by training samples. The input mode X_p, λ_{ji} is the weight between the i neuron and the j neuron in the later layer, β_j is the j neuron, and r_t is the expected output value of the t neuron in the output layer. The actual output of neurons in each layer is calculated successively according to the V is obtained:

$$W = \frac{1}{2}\sum_{t=1}^{n}(r_t - u_t)^2$$

If the output layer neuron: $\varepsilon_t = u_t(1-u_t)(r_t - u_t)$. If the hidden layer neuron: $\varepsilon_j = u_j(1-u_j)\sum \varepsilon_j \lambda_{ji}$

Modified weights and thresholds:

$$\lambda_{ji}(t+1) = \lambda_{ji}(t) + \zeta\varepsilon_t u_t + \chi[\lambda_{ji}(t) - \lambda_{ji}(t-1)]$$

$$\beta_j(t+1) = \beta_j(t) + \zeta\varepsilon_j + \chi[\beta_j(t) - \beta_j(t-1)]$$

ζ is the learning rate, χ is the smoothing factor, and $0<\zeta<1, 0<\chi<1$.

IV. SYSTEM FUNCTION REALIZATION

A. Enclosure Structure Performance Setting Module

The function setting of the wall is mainly to manage the data of the walls, doors and Windows, floors and roofing components. In CeData_Pro, a connection is created for the Construction List in CeData_Pro. The software can provide additional data for each structural unit and modify and store it. The information management function of the wall is realized in the Revit system (Figure 4 is quoted in A BIM Based Digital Framework for Hotel Renovation Projects: An Integrated Application of 3D Scanning and Prefabrication Technology). The construction data of the wall mainly includes the heat transfer coefficient, thermal resistance, thermal inertia, heat storage coefficient, attenuation coefficient, color, recovery rate and so on. The drop-down menu of build names automatically reads all build classes from the CeData_Coe building list. The information processing of Windows, doors, floors and roofs is basically the same as the information processing of walls. Interfaces are processed in the same way as wall construction data.

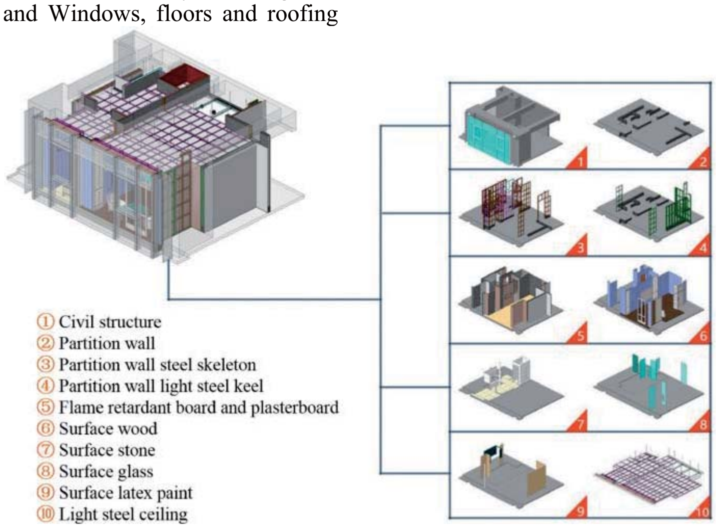

Fig. 4. Wall building information management architecture

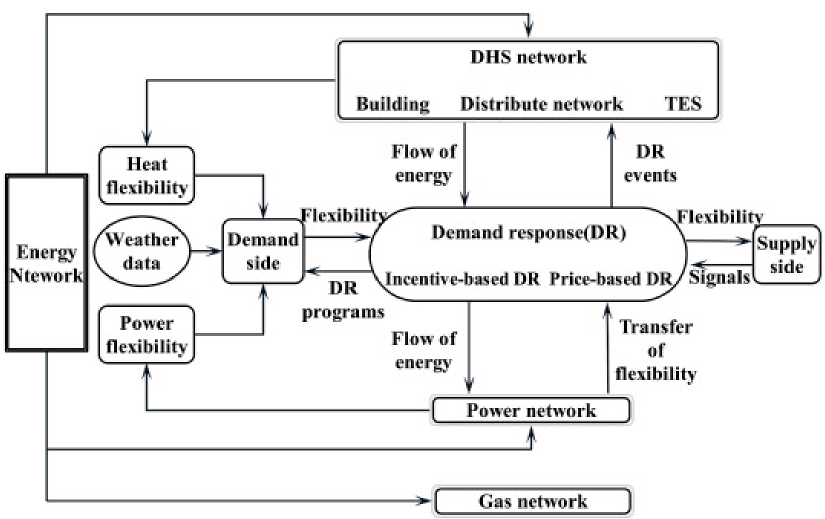

Fig. 5. Hot zone information management

B. Hot Area Utilization Data Unit

The hot zone utilization information module includes the data of the hot zone and the management interface of the working time of the building, which can realize the management of each energy parameter in the hot zone and effectively control the working arrangement of the building [10]. The Hot Zone Information Management window enables the management of "hot" targets in Revit (Figure 5). Its main characteristics are: summer air conditioning indoor temperature, summer air conditioning indoor air relative humidity, winter heating indoor air relative humidity, personnel density, lighting density, ventilation times, power equipment power, cold and heat source type, terminal form, heat load type. First of all, in CeData_Pro you can create a "link" in "CeZone" and "ZoneList". The initial value of this dialog box, similar to the building information management dialog box on the wall, is a related and text-related result preset by the software, and the user can change the related objects according to their needs. You can also create a ZoneList with links.

C. Use the Energy Consumption Prediction Information Screening Module

In the column of "Engineering Data", the numerical values of each structural parameter of the project can be automatically extracted. In the column of "Filter conditions", the value range of each building parameter can be set, according to which the energy consumption monitoring data applicable to the existing building can be selected to predict the energy consumption of the existing project [11]. The relationship model of CeData_Pro and CeData_Mor based on data filtering. Building performance indicators of building availability include: city, building orientation, building size coefficient, heating area ratio, etc. Each building parameter can be passed by CeData_Mor's BuildingInfor architecture. The city, Building type, size coefficient and building orientation correspond to the building's address, structure, ShapeCoeff and owner domain respectively; The heating area ratio can be calculated from the AreaSum area in the building group and the area of each ZoneList internal file; The K domain of envelope set, which can be determined by the Orientation field to determine whether the set is external wall, internal wall or roof. The Window wall ratio can be calculated from the Area field of the Envelope collection and the Area field of the Window collection. The initial value of the project information column can automatically extract the existing information of the current project through the program, and the designer can modify it according to the actual situation; The initial value of the filter condition column is given by default by the system, and designers can also modify it according to actual needs.

V. Conclusion

Develop a Revit-based building carbon emission prediction model. Firstly, the running process and environment of the software are determined. The system is divided into four modules: wall performance setting module, hot area utilization information module, energy consumption prediction information screening module and statistical results module. Secondly, the function and interaction of each module are explained in detail. Finally, using the developed prototype system, the model of carbon emission accounting and data integration is experimentally studied. Carbon dioxide emissions over the entire life cycle are projected at the early stage of the project. Thus, designers can adjust the design scheme according to the feedback information and promote the low-carbon building.

Acknowledgements

The study was supported by (2023R475009) "Research on Emission Reduction Renovation of Existing Buildings Based on BIM Technology"; Taijiaogao (2023) 2 College Students' Technological Innovation of Tai Zhou"Research on Reducing Emissions from Existing Buildings based on bim".

References

[1] Zhao Xiaonan, Xie Xinlian, ZHAO Ruijia. Carbon emission prediction method of railway transportation system based on sliding window dynamic input LSTM network. Traffic Information and Safety, vol.41, pp. 169-178, January 2023.

[2] Li Chaowen, Yin Ruixue. Optimization of NC milling parameters based on tool life and process carbon emission prediction. Tool Technology, vol.57, pp. 80-85, September 2023.

[3] Qi T Q, Li M Y, Yang J X, et al. Construction of 28-day and 90-day prognotic models for patients aged 65 years and older with severe lower respiratory tract infection. International Respiratory Journal, vol.43, pp. 1450-1457, December 2023.

[4] Li Qiaochu, Chen Junhua, He Jing. Long-term trend prediction of regional carbon emission based on System dynamics-Visual Studio integrated model: A case study of Sichuan Province. Environmental Pollution and Control, vol. 44, pp. 1669-1675, December 2022.

[5] CAI Dong, GUO Chunxiang, Bai Lian. Multi-attribute procurement auction considering building greenness under different subsidy objects. Journal of Systems Management, vol. 32, pp. 488-498, March 2023.

[6] Zhao Yan-Ge, Sun Qian, Wei Wan, et al. Study on the influence of building structure type and scheme on carbon emission. Building Structures, vol.53, pp. 14-18, July 2023.

[7] Yang Qing, Peng Ruohui, Liu Xingxing, et al. Study on influencing factors of provincial carbon emission based on geographical weighted regression. Journal of Environmental Engineering and Technology, vol.13, pp. 93-98, January 2023.

[8] Liu Renhuan. Research on green building development problems and countermeasures in Hunan Province under the goal of "dual carbon". Construction Economics, vol.44, pp. 354-358, January 2023.

[9] CAI Binqing, HUANG Yujing, HUANG Xinhuan. Evolutionary game analysis of green building supply under complex environmental regulation. Systems Science and Mathematics, vol. 42, pp. 16-22, December 2022.

[10] Zhao Yan-Ge, SUN Qian, Wei Wan. Study on the influence of building structure design on carbon emission. Building Structures, vol. 53, pp. 19-23, July 2023.

[11] Chang Shasha, FENG Cong Cong, Cui Hang, et al. Prediction and analysis of carbon emission characteristics and emission reduction potential of building industry. Journal of Shenyang Jianzhu University: Natural Science Edition, vol. 39, pp. 139-146, January 2023.