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Computer-Aided Design AND APPLICATIONS

The Application of Graph Neural Network and Computer-Aided Design in the Optimization of Architectural Spatial Layout

Guimin Ma[1] and Jialin Hou[2]

[1,2] School of Architecture and Urban Planning, Henan University of Urban Construction, Pingdingshan, Henan 467036, China, [1]maguimin@huuc.edu.cn, [2]20172111@huuc.edu.cn

Corresponding author: Jialin Hou, 20172111@huuc.edu.cn

Abstract. In many aspects of architectural design, the optimization of spatial layout is particularly important, as it is directly related to the practicality, comfort, and aesthetics of the building. The objective of this research is to investigate the utilization of graph neural networks (GNN) and computer-aided design (CAD) in refining the layout of architectural spaces. In response to the disorderly expansion in the current building configuration, the development of urbanization has entered a relatively complex relationship. This article introduces a visual quick layout framework for building configurations. Analyzing the inherently complex relationship between GNN and architectural space constructs a visual architectural spatial configuration. Compared with traditional methods, the overall design appears more coherent and efficient. Among different functional requirements, it has higher functional requirements in method layout, which improves the efficiency of architectural design in overall design. In improving the architectural layout of GNN and CAD, the development of urban planning is also reflected differently in the integration of regions.

Keywords: GNN; CAD; Optimization of Architectural Spatial Layout; Ecological Plot Ratio
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1 INTRODUCTION

Realistic 3D models can be combined with basic geographic information data to serve urban planning, construction, management, and other aspects [1]. This poses new challenges to the processing, storage, and transmission of existing high-resolution 3D building model data. With the rapid development of data collection technology, it presents fine and complex data features and larger data volumes [2]. The current main solution in academia is to use the Level Of Detail model; LOD is used to express three-dimensional building models [3]. To solve the problem of low query index and computational efficiency in large-scale urban 3D building model data. How to efficiently store, manage, query, and compute multi-resolution 3D building model data in large-scale urban scenes is also one of the challenges faced [4]. Reuse data organization and management methods that conform to the structure of 3D building models for data management. However, existing methods for simplifying 3D building models often overlook texture factors, resulting in texture distortion and loss of detailed features in the simplified model [5]. In the process of simplifying 3D building models, texture features are introduced, and a model simplification method that takes into account texture features has been developed. While minimizing the amount of data and complexity of the model, important geometric and visual features of the model are preserved. Thus achieving hierarchical management of multi-resolution 3D building model data, thereby improving the query, retrieval, and computational efficiency of building models [6]. A method for organizing and managing multi-resolution 3D building model data based on a global location grid. On this basis, focus on the data organization and management requirements of 3D building models, and further introduce global location grids to organize and manage multi-resolution 3D building models. The key to generating LOD is to simplify the model to reduce its complexity, thereby achieving the goal of reducing the amount of model data. In response to the problems of existing 3D building model simplification algorithms not being able to preserve model detail features well and easily causing texture distortion, the focus is on the simplification of models and the organization and management of model data, specifically including a 3D building model mesh simplification algorithm based on "local vertex" texture features. We have conducted research on simplification techniques for 3D building models that take into account texture features.

Revit Architecture is currently the mainstream 3D architectural design software. The Rvt file contains geometric and attribute information of the building model, and the private data format is not supported on the website. By combining Revit 3D building models and WebGL display technology, the Revit Architecture 3D building model is reconstructed and displayed in the browser through WebGL, achieving model-associated attribute queries and LOD display optimization technology based on Revit "family" objects [7]. Use Revit API to separate geometric information and attribute information, and convert geometric information into OBJ format files. Implemented the function of quickly modelling on the browser end using the 3D display technology of the WebGL graphics library. Store in the geometric area and attribute area of the JSON file, respectively. Parse JSON files through WebGL to achieve display purposes. The conversion of the Rvt model format to a JSON intermediate file was achieved through Revit API. With the rapid development of CAD technology, remote sensing technology, photogrammetry technology, and GIS technology, we are now able to accurately reproduce three-dimensional surface landscapes and have been widely applied in various fields such as urban planning, architectural design, and landscape design. The advantage of CAD models in expressing three-dimensional spatial information lies in their speed and realism, which has attracted much attention in the field of landscape design [8]. These models not only contain geometric information about terrain and spatial location of features but also texture image information that describes the true coverage range of the ground. Driven by multiple factors such as economy, culture, and technology, CAD technology is no longer a single calculation tool but has become an important auxiliary technology in multiple fields, such as architectural space design, architectural structure design, and landscape creation. This model integrates AI algorithms and CAD technology to achieve intelligent analysis and optimization of the spatial pattern of garden landscapes. next, AI algorithms propose spatial layout optimization suggestions based on design rules and user needs. Both BIM and GIS can display 3D models very realistically, but there are specialties in the field. The former focuses on recording detailed information about buildings and constructing internal spaces, while the latter focuses on large-scale geographic scene visualization and spatial analysis, which inevitably leads to their respective limitations. Lack of the ability to finely visualize the surrounding environment of buildings, as well as the ability to analyze geographical terrain and external space [9]. Committed to integrating and applying the attribute information of buildings throughout the entire lifecycle of construction projects, based on its concept, the building and equipment facilities information throughout the entire process of the project have a high degree of consistency. For individual building models, there is an issue of information silos, as the area they can display is very small. The large-scale geographic scenes simulated through 3D GIS technology can more fully reflect the spatial structure relationship between buildings and the surrounding environment. The main object of BIM is a high-precision individual building model, and the information covers the entire lifecycle of the project [10]. It can accurately locate and analyze buildings, store massive three-dimensional geographic data at a macro level, and support large-scale visual displays of scenes. High model accuracy, parameterized design, and rich semantic information are the characteristics of BIM technology, which is mainly used to construct structural models of the interior space of buildings. GIS technology is an important means of urban construction and management, mainly describing the spatial geographic information of objects on Earth with a large and scientific geographic information database. 3D GIS can be used to query spatial information and analyze the spatial environment of building models, providing decision support for projects. Similarly, when GIS lacks BIM technology support, the display and analysis of scenes will remain outside the building.

By amortizing the strengths of these two technologies, we anticipate surpassing the constraints of traditional design methodologies and propelling the architectural design industry toward a more scientific, intelligent, and efficient future.

(1) The combination of GNN and CAD technology brings a new design idea of data-driven and quantitative analysis, which helps to understand the relationship between spatial layout and architectural function and comfort more accurately.

(2) This article expounds on the advantages of GNN and CAD technology in the optimization of architectural spatial layout, including extracting hidden rules, quickly generating and modifying design schemes, and realizing the intelligence of the design process.

(3) The challenges in the application of GNN and CAD technologies, such as data acquisition and processing, model training and optimization, and the interconnection of design tools, are also discussed, and the solutions to these problems will be further explored in future research.

The article first elaborates on the importance of optimizing architectural spatial layout and the potential of combining GNN with CAD technology. Subsequently, it provides a detailed introduction to related technical research, methodologies, and experimental analysis. Through architectural cases, it explores the practical application effects. Finally, the discussion and outlook section, raises the limitations of the technology and its future development direction, summarizing the main findings and contributions of the entire article in the conclusion section.

2 RELATED WORKS

Currently, landscape design and scene element rendering also rely on computer-aided design. This method not only improves the effectiveness of design education but also provides strong technical support for the optimization of future architectural spatial layouts. Li [11] constructed a rich 3D graphics engine rendering image library through multi-angle and multi-perspective scene design and display. As an important component of cultural landscape heritage, the maintenance and inheritance of garden structural design are increasingly valued. With the continuous development of computer technology, digital development has become an important means of handling cultural heritage. Liang et al. [12] used sensors on unmanned platforms for image acquisition, which can obtain high-precision point cloud image data, providing strong data support for digital modelling and simulation of garden structure design. This method not only enhances the diversity of plants but also greatly improves the overall landscape pattern, providing richer materials and inspiration for optimizing the spatial layout of buildings. We explored the application of auxiliary intelligent technology in landscape rendering of terrain planning and planting design elements. In indoor architecture education, exploration has begun to explore the design of computer-aided drawing programs, using professional software tools to process data collected from various indoor architecture and environmental design tutorials. With the rapid development of technology, computer-aided drawing of architectural landscape design has become a standard feature in the industry. Therefore, the introduction of computer-aided design technology has greatly improved the efficiency and quality of design. Due to differences and shortcomings in programming, traditional architectural landscape design methods often struggle to achieve efficient and centralized project planning. Safikhani et al. [13] combined artificial intelligence with big data analysis technology to intelligently optimize spatial layout and achieve maximum utilization of spatial resources.

Computer-aided design technology plays a crucial role in optimizing architectural spatial layout. By accurately measuring and analyzing architectural space, designers can more accurately grasp the efficiency and functional requirements of space utilization.

In the 3D design analysis of the rock rockery garden, Shan and Sun [14] used 3D laser scanning and digital technology to record the shape of the classical garden in detail and conducted in-depth research on the structure of the rockery. In the field of architectural landscape construction engineering, the digital transformation of the digital resource management process is an important trend. In addition, the application of BIM technology can achieve refined resource management through digital building information, providing comprehensive and accurate data support for optimizing building spatial layout. By using advanced sub-algorithms and a power system for virtual images, the energy consumption of the rendering process has been effectively controlled, and the stability of batch processing of landscape images has been optimized. When analyzing the low-energy application of CAD virtual-assisted design in landscape design, the focus is on how to reduce energy consumption in the landscape design process through technological innovation. The application of these technologies not only reduces costs but also improves design efficiency, providing more environmentally friendly and efficient design solutions for optimizing building spatial layouts. Through investigation, measurement, and analysis of garden rockeries in different situations, Tai [15] developed a digital literature research method that can provide reference and guidance for optimizing the spatial layout of modern architecture. By constructing CAD digital models, the effect of building spatial layouts can be more accurately simulated and predicted, filling the gap of virtual technology in landscape resource protection. In the process of exploring the optimization of architectural spatial layout, a dynamic visualization three-dimensional geographic perception visualization analysis model was constructed. Through in-depth research on transportation and other challenges, this model can provide strong support for real-time positioning of construction projects, ensuring optimization of spatial layout and coordination with the surrounding environment. This model not only helps us better understand the complex relationships in geographic space but also provides real-time and dynamic data support for optimizing building spatial layouts. The actual effect of feature extraction in the scheme data was transformed from the perspective of public interest and evaluation coefficients. We also conducted a construction analysis on the integrated virtual landscape design environment. The accuracy of the distributed geographic model was restored through computer-aided design. The research results indicate that the distributed integrated model has significant accuracy advantages in landscape design and architectural spatial layout optimization, and can provide a more accurate and reliable design basis. In architectural spatial layout optimization research, traditional methods often rely heavily on designers' expertise and experience, involving repeated scrutiny and adjustments via handwritten sketches and models. Some building models have a large number of complex structures and independent components, and adjacent structures can affect and correlate with each other. Moreover, due to the texture mapping of the 3D model embedding the 2D texture space into the 3D mesh, simplification of the model may result in stretching or compression of the 3D mesh model, leading to texture distortion in the building model after texture mapping. Directly applying the general 3D model simplification algorithm to the simplification operation of 3D building models often cannot achieve good application results, so it is necessary to conduct separate research on the simplification of 3D building models. On the other hand, it is due to the complex texture patterns in some structures of 3D building models. In order to improve the efficiency of organizing and scheduling massive 3D building models in 3D scenes, it is necessary to start from the structural and attribute characteristics of the 3D building models themselves. In the simplification of 3D building models, texture is considered as a factor, while minimizing the amount of data and complexity of the model, while still retaining important geometric and visual features of the model. With the introduction of the concept of realistic 3D, there is an increasing amount of research on simplifying 3D building models, but there is relatively less consideration for texture in the research. Use a unified spatiotemporal reference framework to organize and manage multi-source heterogeneous 3D building model data in 3D scenes. To carry and support applications in various industries, this is of great significance for improving the query, retrieval, and computational efficiency of model data. So as to achieve better visual effects in the use of the model. It is of great significance for the construction of realistic 3D scenes.

3 CONSTRUCTION OF OPTIMIZATION MODEL OF ARCHITECTURAL SPATIAL LAYOUT

The optimization model of architectural spatial layout proposed in this article is an integrated system based on GNN and CAD. Firstly, the system uses GNN to carry out deep learning and pattern recognition on the spatial layout of buildings and extracts the key features and relationships in the spatial layout. Then, combined with CAD technology, the design scheme is quickly generated, evaluated, and optimized. The whole model is divided into three main parts: data preprocessing, GNN learning, and CAD optimization. Data preprocessing is the first step of the model, which involves the collection, cleaning, and formatting of building case data. We have collected a large number of architectural case data from open architectural design databases and professional design institutions, including plan, elevation, section, and related design parameters and labels. After cleaning and standardization, these data are converted into graph structure data suitable for GNN processing. Each architectural case is represented as a graph, in which nodes represent architectural spaces (such as rooms and corridors), and edges represent the relationships between spaces (such as adjacency and connectivity). Each node contains a series of features, such as space type, area, shape, etc., which will be used as input for GNN learning.

Figure 1 clearly shows the spatial adjacency between rooms in a typical residential design, providing an intuitive perspective to understand the relative positions and connection modes between rooms. In addition, in order to analyze the accessibility and spatial layout between rooms further, a depth map can be used to describe them further. This kind of depth map can describe in detail the path hierarchy, that is, "depth," that needs to be passed from outdoors to each room. In this way, rooms can be arranged in a hierarchical way according to the sequence and path length of entering rooms, and the connection lines between them can be drawn. Such a depth map not only helps to grasp the spatial structure of the house fully but also optimizes the streamline in the design stage and enhances the living experience. Through this visualization method, designers can plan the room layout more scientifically and ensure the functionality and comfort of the house.

	1	2	3	4	5	6
1. Sitting room		1	-1	2	0	1
2. Dining room			0	0	-1	-1
3. Kitchen				1	0	0
4. Bedroom 1					1	0
5. Bedroom 2						2
6. Toilet						

Figure 1: Example of adjacency matrix of rooms in residence.

As shown in Figure 2, designers play a vital role in the whole design optimization process. In the problem definition stage, designers need to rely on their professional knowledge and rich experience to accurately identify and define the key problems that need to be optimized so as to lay a solid foundation for the subsequent optimization work. In the process of concept presentation, designers use creative thinking to propose creative and practical spatial layout concepts, which inject inspiration and vitality into the optimization process. In the step of parameter setting, designers need to carefully adjust various parameters to ensure that they can not only reflect the design requirements but also provide clear guidance for optimizing technology. Finally, at the end of the whole design process, optimization technology, as a strong support, finds the optimal solution for the architectural space layout according to the parameters and problem framework set by the designer, thus ensuring the practicability of the design scheme.

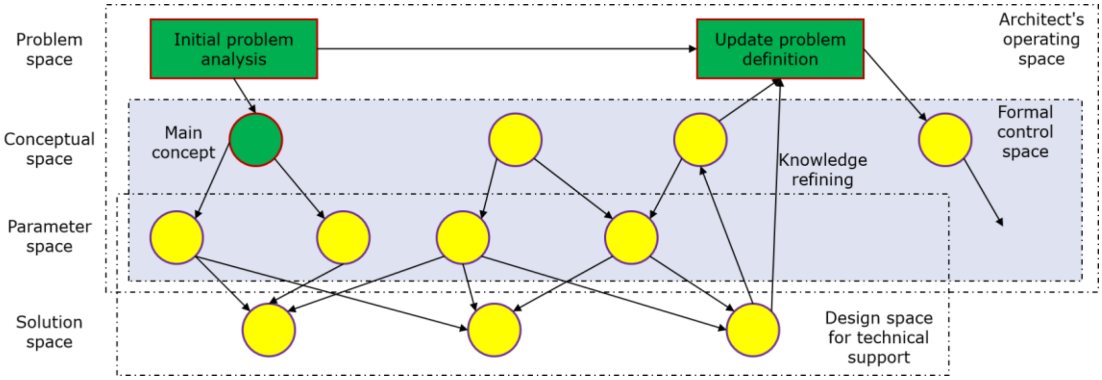

Figure 2: Collaborative optimization of reciprocating iteration in four spaces.

Aiming at the complexity and particularity of architectural spatial layout, this article puts forward a brand-new GNN model. This model not only inherits the powerful learning and generalization ability of the BP neural network but also introduces graph structure data, which enables the model to capture and understand the internal relations and dependencies between architectural space elements more deeply. The convolution operation process is shown in Figure 3.

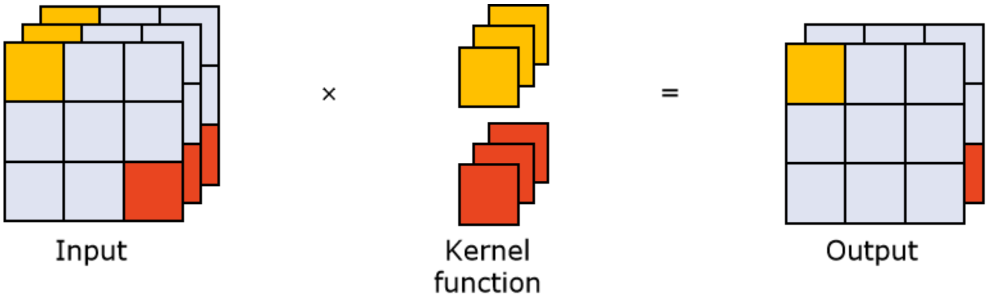

Figure 3: Convolution operation.

GNN learning is the core part of the model, which is responsible for extracting useful information from preprocessed data. In the process of GNN learning, each node updates its own state by aggregating the information of its neighbour nodes. The optimization process is carried out by iteration until the design requirements are met or the preset optimization times are reached.

GNN is a neural network that can process graph structure data. It extracts features and makes predictions by learning the relationship between nodes. In this model, each room is regarded as a node, and the connections between nodes represent the channels between rooms. Use the following formula to define the propagation mechanism of GNN:

$$h_i^{t+1} = \sum\nolimits_{j \in N\ i} \frac{1}{c_i} \cdot W \cdot h_j^t \tag{1}$$

Where h_i^{t+1} represents the hidden state of node i at time step $t+1$, W represents the weight matrix, $N\ i$ represents the neighbor node set of node i, and c_j represents the degree of neighbor node j.

A CAD software named Blender is used as a design tool. In this study, an interface is developed to combine the output of the GNN model with the parametric model of Blender software. Through this interface, the optimization results of the GNN model can be directly applied to the building model in Blender software, and a new design scheme can be generated.

The proposed architectural spatial layout optimization method combines the advantages of GNN and CAD to generate a high-quality architectural design scheme in an automatic way. Use the following formula to define the optimization goal:

$$L=\sum_{i=1}^{N}\sum_{j=1}^{M}\ \sigma_i^j-t_i^j\ ^2 \tag{2}$$

Where L represents the loss function, o_i^j represents the target optimization value of the i room at the j time step, t_i^j represents the current optimization value of the N room, M represents the total number of rooms and HH represents the total number of time steps.

Use the GNN model to predict the optimal values of each room, and then use Blender software to apply these optimal values to the building model.

In GNN, weight updating is a key step, which determines how the network learns the relationship between nodes:

$$W_{ij}=W_{ij}+\alpha\cdot\ h_i\cdot h_j^T-W_{ij} \tag{3}$$

Where W_{ij} represents the weight of connecting nodes i and j, h_i and h_j represent the hidden states of nodes i and j respectively, and α represents the learning rate.

Architectural models in CAD software are usually represented by parametric models, which can modify the design by adjusting parameters:

$$x=x_0+A\cdot t \tag{4}$$

Where x represents the state of the current building model, x_0 represents the state of the initial building model, A represents the model parameter matrix, and t represents the parameter vector.

In the optimization of architectural space layout, we usually pay attention to multiple objectives, such as space efficiency, ergonomics, and aesthetics. Use the following formula to define a comprehensive, objective function:

$$F\ x\ =\lambda_1\cdot f_1\ x\ +\lambda_2\cdot f_2\ x\ +\lambda_3\cdot f_3\ x \tag{5}$$

Among them, $F\ x$ stands for the comprehensive objective function, $f_1\ x$, $f_2\ x$ and $f_3\ x$ stand for the objective functions of space efficiency, ergonomics, and aesthetics respectively, and λ_1 , λ_2 and λ_3 stand for the importance weights of these objectives respectively.

Define $g_{\min},g_{\max}$ as the grey value range of the original 3D image of the building space, denoted as $f\ x,y$. Choose a suitable threshold labelled as T , and proceed as follows:

$$g_{\min}\le T\le g_{\max} \tag{6}$$

The formula below represents image segmentation utilizing a sole threshold:

$$g(x,y)=\begin{cases}1, & f(x,y)\geq T\\ 0, & f(x,y)<T\end{cases} \tag{7}$$

$g(x,y)$ constitutes a binary image, where the process of binarization effectively highlights the object against the background. The crux of binarizing architectural space's 3D images lies in the judicious choice of the threshold, denoted as T.

During the training of GNN, the disparity between the predicted and actual values is gauged by employing a loss function, which can be defined using the subsequent formula:

$$L=\frac{1}{N}\sum_{i=1}^{N}\gamma(y_i,\hat{y}_i) \tag{8}$$

Where L stands for the loss function, N stands for the total number of samples, y_i stands for true value, $\hat{y}_i$ stands for predicted value and γ stands for the loss function, such as mean square error or cross-entropy loss.

In CAD software, iterative optimization is used to improve the design gradually;

$$x_{n+1}=x_n+\alpha\cdot\nabla_x F(x_n) \tag{9}$$

Where x_{n+1} represents the state of the next iteration, x_n represents the current state, α represents the learning rate and $\nabla_x F(x_n)$ represents the gradient of the objective function $F(x)$ at the current state x_n.

4 OPTIMIZATION EXPERIMENT OF ARCHITECTURAL SPATIAL LAYOUT

4.1 Layout Rationality

According to the display of Figure 4, Figure 5, and Figure 6, it can be clearly seen that in the architectural layout designed by the method proposed in this article, residential areas and schools are cleverly arranged in similar positions. This kind of planning not only facilitates students' entry into the school nearby, reduces commuting time and distance, but also facilitates the design of the transportation network in this area, further enhancing the convenience of students' further studies. At the same time, the design presents a clear and regular aesthetic feature from the grid layout. The buildings in each functional area are closely related, forming a harmonious and efficient urban architecture "ecosystem."

In contrast, the architectural layout method adopted in reference [9] places shopping malls in the centre of residential areas. Although this design is convenient for residents' daily shopping to a certain extent, it also brings a lot of noise to residential areas because of the surging crowds brought by shopping malls, which may further affect residents' living satisfaction. In addition, this method also arranges schools and hospitals relatively close. Considering the high density of daily people flow in hospitals and the possible risk of cross-infection of germs, this layout is obviously not suitable for the school environment and poses a certain potential threat to students' health and safety.

Upon examination of the layout scheme proposed in reference [10], it becomes evident that it lacks a distinct functional zoning. The apparent randomness with which various buildings are scattered across the space creates an overall sense of disorderliness. Such a haphazard layout not only poses potential inconveniences to residents but also undermines the long-term planning and sustainability of the city's development.

Drawing from the aforementioned analysis, it is evident that the method advocated in this article exhibits significant strengths in architectural layout design. It effectively caters to the diverse needs of residents, students, and other stakeholder groups while simultaneously reflecting a deep comprehension of urban planning aesthetics. This harmonious blend of practicality and aesthetics in the layout scheme unequivocally validates the soundness of the approach put forth in this article.

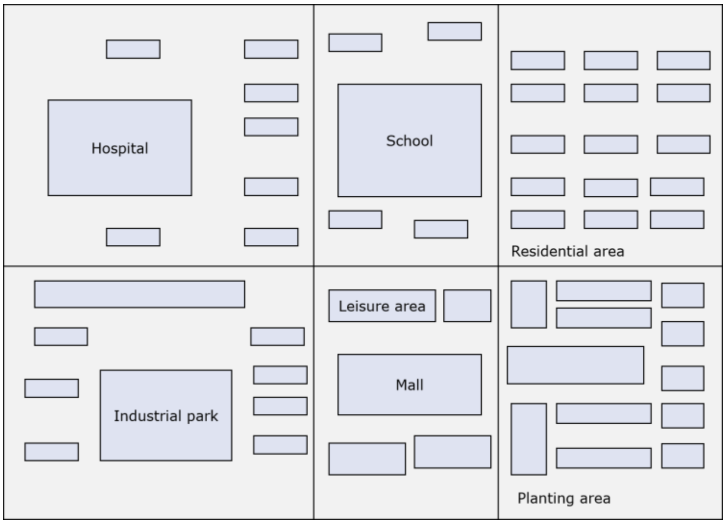

Figure 4: Layout effect of this method.

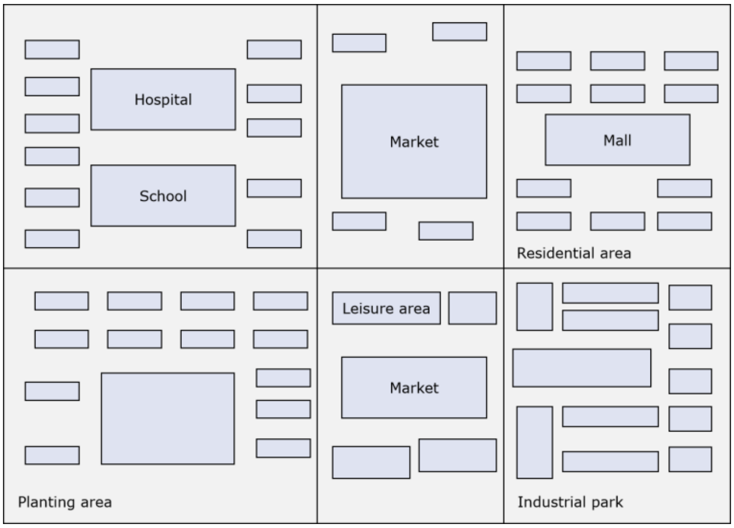

Figure 5: Layout effect of reference [9] method.

4.2 Carbon Reduction Situation

To thoroughly assess the impact of different layout optimization techniques, this study utilizes the connectivity between building modules as the primary metric for comparative analysis. We compare the optimization outcomes achieved by the method introduced in this paper, the approach described in reference [9], and the method outlined in reference [10]. Detailed testing of these outcomes has been conducted, and the findings are presented in Figure 7. In this test, connectivity is quantified by a specific numerical value, and its numerical range is set between [0,1]. In this range, the larger the value, the higher the connectivity between buildings, that is, the accessibility and interactivity between buildings are superior.

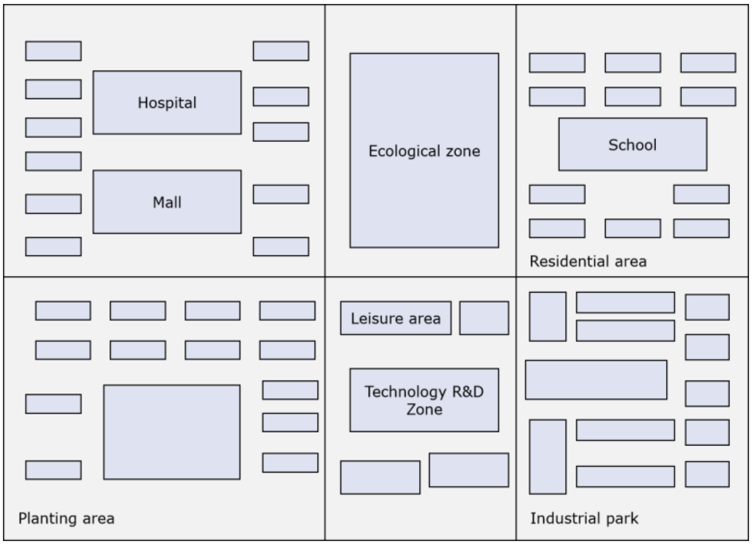

Figure 6: Layout effect of reference [10] method.

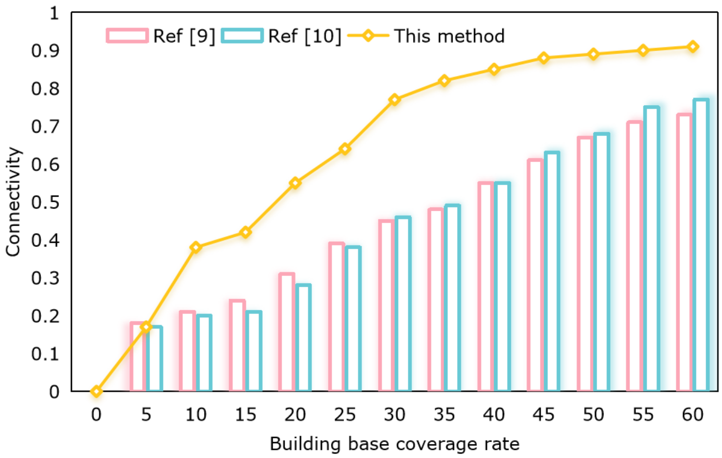

Figure 7: Carbon reduction by different methods.

Under the same coverage of building basements, the method proposed in this article shows significant advantages in optimizing the connectivity between buildings. Whether in the case of low coverage or high coverage, the connectivity value of the proposed method is higher than that of the methods in reference [9] and reference [10]. In particular, under the condition of 45% building basement coverage, the connectivity value of the layout optimized by this method is as high as 0.89, which fully proves the excellent performance of the proposed method in building spatial layout optimization.

This result not only shows the effectiveness of this method in improving the connectivity between buildings but also further verifies the profound understanding and accurate grasp of the architectural layout in complex urban environments. Through the optimized layout, not only the utilization efficiency of urban space is improved, but also the communication and interaction between buildings are greatly enhanced.

4.3 Ecological Floor Area Ratio

To further validate the efficacy of the method proposed in this paper, the ecological volume ratio has been chosen as the primary evaluation criterion. The ecological plot ratio serves as a direct indicator of the optimization effectiveness of the architectural spatial layout: a higher ecological plot ratio signifies a superior layout in terms of environmental conservation and greening, whereas a lower ratio indicates a need for layout improvement. To comprehensively assess the optimization outcomes of various methods, ten representative target zones were handpicked for optimizing the spatial arrangement of buildings. Within these zones, the method presented in this article, as well as the approaches documented in references [9] and [10], were utilized to refine the layout. Detailed statistics and comparisons of the respective ecological plot ratios were conducted. The results of this assessment are visualized in Figure 8.

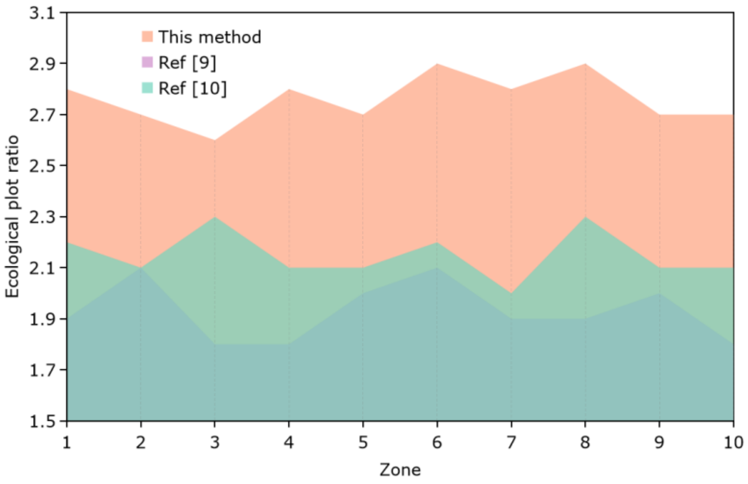

Figure 8: Ecological plot ratio of different methods.

The method proposed in this article shows obvious advantages in ecological volume ratio. Compared with the methods in reference [9] and reference [10], the ecological plot ratio of the proposed method keeps a leading position in any target area. This outstanding performance stems from the in-depth analysis of the present situation of architectural spatial layout before layout optimization, and based on this, an accurate optimization model of architectural spatial layout is constructed. This model not only fully considers the regional characteristics, but also closely combines the concept of green and low-carbon urban development, thus effectively improving the ecological floor area ratio and further verifying the effectiveness of the proposed method.

4.4 Discussion

This article constructs a three-dimensional model scene of architecture and geographical environment by combining GNN modern information technology. Exploring the technology and path of GNN management integration based on the platform. Architecture is a precious historical and cultural heritage that has been extensively damaged in the face of natural disasters, human wars, and urbanization. And according to this technology route, achieve the positioning restoration and display of the building, in order to reflect the potential advantages and application prospects of the integration of these two technologies. The integration of GNN models with GIS platforms will inevitably lead to issues such as data redundancy, high operational load, and model mismatch with the surface. Due to the large amount of data in BIM models and the emphasis on spatial scene display in GIS platforms. This article explores the idea of data conversion by comparing the differences and commonalities between the standards adopted by the two technologies while preserving the rich semantic information of BIM architecture as much as possible. The difference in application standards has caused the biggest gap between BIM models and 3D GNN models, making it impossible to directly convert and integrate them.

In the process of building the system, the following three aspects are mainly studied: converting BIM model data to GNN model. And use the Revit model conversion plugin provided by the SuperMap platform to solve the problem of GNN model data integration with the GIS platform. GNN technology data fusion has great potential advantages and broad application prospects. This article will import the Revit model of a small villa as a practical object into the SuperMap platform, and solve the technical difficulties of geographic data caching, terrain matching, and model optimization through the platform's functions. Using modern information technology of GNN, construct a BIM model of ancient architecture with detailed information and conduct virtual roaming through the GNN platform. So as to break down the barriers of time and space, restore the true position of the building, and enable it to be represented.

5 CONCLUSIONS

Realistic 3D China requires the construction of a digital 3D space that is interconnected with the real world, providing high-quality spatiotemporal information products and services for the construction of Digital China. And use data organization and management methods that conform to the structure of 3D building models to solve the problem of low query index and computational efficiency of large-scale urban 3D building model data. Among them, the construction results of the 3D building models that make up the realistic 3D models are widely used in the construction of smart cities. It can be combined with basic geographic information data to serve urban planning, construction, management, and other aspects. With the rapid development of data collection technology, the processed 3D building models have become increasingly refined and complex. The existing high-resolution 3D building models have limited the further development of 3D visualization applications in terms of data processing, storage, and transmission.

This article aims to verify the effectiveness and efficiency of a multi-resolution 3D building model organization and management method based on a global location grid in large-scale urban 3D building model scenarios. Therefore, this chapter designs a three-dimensional visualization system for urban building clusters based on the GNN architecture. This chapter elaborates on the architecture design and required functions of the system. A multi-scale representation of experimental data from a 3D building model dataset was conducted. And the results of multi-scale query and retrieval of 3D building models using global location grids.

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Guimin Ma, https://orcid.org/0009-0006-5133-4600
Jialin Hou, https://orcid.org/0009-0002-0107-2869

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