Design and Implementation of the Shared Street Landscape Reconstruction Simulation System Based on BIM Technology

Yi Gao[a*], Mingxing Luo[b] and Kun Zhang[c]

[*]Corresponding author's e-mail: [a]16865802@qq.com
[b]2461303213@qq.com, [c]15941830@qq.com

Chengdu vocational university of the arts, Chengdu 610041, Sichuan, China

Abstract. The analytical method is generally used for 3D image modeling in urban public green space projects, but this method has some problems, such as weak index correlation, slow reconstruction speed and poor image quality. Therefore, we propose a shared street landscape reconstruction simulation system design scheme based on the shared street Landscape Information Model (BIM) technology. BIM technology provides a practical solution for the 3D simulation of urban road environment, and we can grasp the 3D simulation process of urban road through dynamic display.3D simulated images of urban public road environment using BM have high clarity and low computational time and better results.

Keywords. BIM technology; shared street landscape transformation simulation system; street landscape simulation modeling

1 Introduction

BIM (Building Information Modeling) with 3D information as the main means, in the same work platform to establish 3D information model, for the design department, construction department and management department built a data sharing and exchange platform, can for road landscaping restoration project put forward a set of complete design, can reduce design errors, improve the quality and efficiency of communication, promote the project progress, to ensure the quality of the project, etc [1]. Through the application of BIM, the engineering design and construction process can be visualized, and the necessary data support for the smooth implementation of the project can be provided through design verification, collision test and other means [2]. Based on BIM technology, a BIM-based urban public block environment visualization simulation platform is constructed, and the design and implementation of the platform are elaborated in detail. The platform can also provide data support for urban planning and management, and help decision-makers to better grasp the development direction and goals of the city [3].

PMBDA 2023, December 15-17, Nanjing, People's Republic of China

DOI 10.4108/eai.15-12-2023.2345385

2 Dimensions of specimens

2.1 Composition of the BIM application module

Currently, the most used BIM system on the market is produced by Autodesk, which covers five modules: CAD engineering design, Civil 3D terrain treatment, Revit building structure modeling, AIM rapid expression and Navisworks building simulation [4]. By importing the building model established by CAD, Civil, Revit and other software, BIM can show the construction state and layout of each stage of the project in real time [5], as shown in Figure 1. In addition, BIM can also present the construction effect and construction progress in a dynamic form, with the help of Navisworks, 3DMax and other 3D modeling tools, the project can be visualized.

2.2 System function design

The simulation system is a tool using information and computer technology to simulate and simulate the complex engineering construction process through the computer, so as to predict and plan the process of the whole project. This system provides convenience for designers and construction units to make plans and decisions at the engineering design stage. This study aims to provide a simple environment for relevant departments to better understand and identify problems in the urban public green space landscape and to provide decision support for urban renewal planning and construction [6].

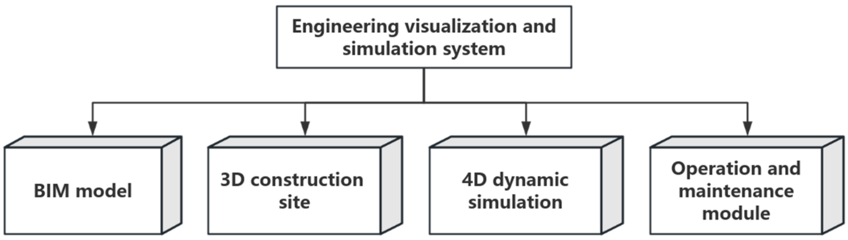

Figure 1. System function design.

Design and implementation of BIM model Using 3D technology to present the results in the form of solid graphics [7]. Building 4D dynamics simulation is to establish a 3D model to give the corresponding dynamic parameters, so that the construction of the project and the project process is more closely linked. Construction site 3D tour is through the virtual reality technology to present the highway layout, landscape greening and other content in the way of virtual reality. The operation and maintenance module is responsible for the maintenance and management of the system basic data.

2.3 System technical architecture

According to the functional design of the system, the architecture system of the system is mainly divided into four levels: application layer, model layer, platform layer and data layer. Details are shown in Figure 2.

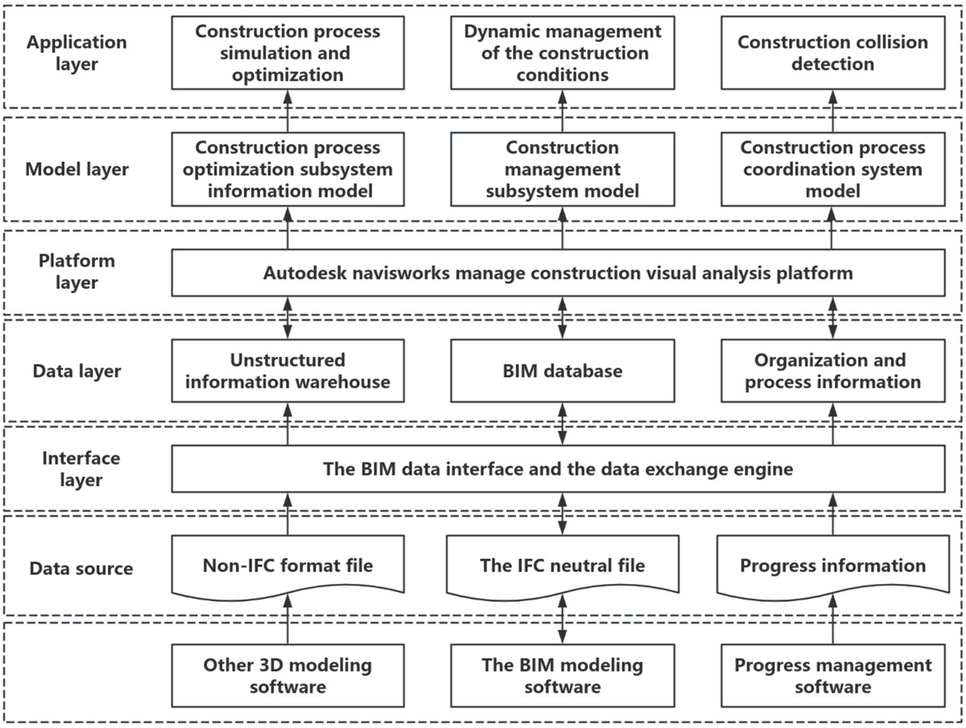

Figure 2. Design diagram of system technical architecture.

2.4 Implementation of the key technologies

2.4.1 Coordinate confirmation based on the spatial interpolation method.

Determining the location of coordinate data points is a key step in 3D modeling, while spatial interpolation methods use the small number of initial sampling points to estimate the required data, providing the corresponding elevation for the construction of the ground model [8]. To determine the relative positions of the individual elements in the public block, the Kriging space interpolation was used.

In three dimensions, the *x, y* coordinates of the point to be estimated are known, and the *z* coordinates need to be confirmed. hypothesis $x_1, x_2, \ldots, x_n$ Represents *x, y* coordinates, *Z* in the spatial position of n coordinate points $Z_i=Z(x_i)$, $i=1,2,\ldots,n$, represents the space of point *i*, the measurement of the *z* coordinate in the position, then has:

$$Z_v^*(x) = \sum_{i=1}^{n} \lambda_i Z(x_i) \tag{1}$$

Where $Z_v^*(x)$ represents the valuation of the z coordinate of the point under evaluation; λ_i represents the weight coefficient of the known point; $Z(x_i)$ represents the effective sample value of the estimated point within the influence range.

To transform the problem to solve the spatial coordinate of the determinable point, the following two conditions must be met:

(1) unbiased estimate

$$E\left[Z_v^*(x)-Z_v(x)\right]=0 \tag{2}$$

(2) Optimal estimation

$$\min\ \left\{\mathrm{Var}\ \left[Z_v^*(x)-Z_v(x)\right]\right\}=\min\ \left\{E\left[\left(Z_v^*(x)-Z_v(x)\right)^2\right]\right\} \tag{3}$$

When the E [Z (x)] = m of the variable Z (x) is a known constant, it is a simple Kriging method, When the E [Z (x)] = m of the variable Z (x) is an unknown constant, The ordinary Kriging law.

Internal stationary conditions:

$$\sum_{i=1}^{n}\lambda_i^0=1 \tag{4}$$

Assuming the required estimate of $Z_0^* = Z^*(x_0)$ Is the observed value Zi , A linear combination of the i = 1, 2, …, n.

$$Z_0^*=\sum_{i=1}^{n}\lambda_i^0 Z_i \tag{5}$$

Through this condition to confirm the coefficient λ_i^0, the objective function is converted to the undetermined coefficient λ_i^0, $i = 1,2,\cdots,n$, A quadratic function form of n. We transform to the unconstrained minimum of the objective function as follows:

$$f(\lambda_1,\lambda_2,\cdots,\lambda_n)=\sigma_{\lambda_0}^0+2\lambda\left(\sum_{i=1}^{n}\lambda_i-1\right) \tag{6}$$

The following Kriging equations are obtained:

$$\begin{cases}\sum_{i=1}^{n}\lambda_j=1\\ \sum_{j=1}^{n}\lambda_j(\lambda_i,\lambda_j)-C(\lambda_i,\lambda_0)+\lambda=0\end{cases},i=1,2,\cdots,n \tag{7}$$

The measurement error is assumed to be Gaussian noise independent of each other, with a mathematical expectation of *0* and a variance of $\sigma_i^2(i = 1,2,\cdots,n)$.The estimated value is:

$$Z_0^*=Z(x_0,y_0) \tag{8}$$

Kriging The system of equations is as follows:

$$\begin{cases}\sum_i\lambda_i^0\gamma_{ij}-\lambda_i^0\sigma_i^2+\mu=\gamma_{i0}\\ \sum_i\lambda_i^0=1\end{cases},\quad i=1,2,\cdots,n \tag{9}$$

The estimated variance is:

$$\mathrm{Var}\left(Z_0^* - Z_0\right) = \sum_i \lambda_i^0 \gamma_{i0} + \mu \tag{10}$$

The Kerikin method can be used to simulate a lot of spatial data points in shared streets to make up for the lack of collected data points.

2.4.2Use Civil 3D to generate the terrain surface.

Civil 3D It is a civil building design software based on BIM workflow launched by Autodesk, with various functions, including terrain construction, earthwork calculation, sanitation equipment layout, flood control simulation, drainage engineering construction, highway planning, etc., and can be applied to many fields such as terrain construction, hydrological analysis, landscaping, etc [9]. It can also establish a simulation system of block style reconstruction, improve the competitiveness of block style, and promote the construction process. At the same time, the 3D simulation of the large-scale road landscape is carried out by means of BIM technology to obtain the dynamic information. In Civil 3D, the surface is a digitized figure that can be divided into two categories: triangular mesh (TIN) and mesh (grid). When building the model, the measurement point data can be entered into the 3D space, e. g .txt and .csv document [10]. In conclusion, Civil 3D is a powerful software that helps designers to carry out complex architectural design and simulation tasks. Civil 3D Can help with collision detection, construction simulation and engineering quantity estimation, greatly reducing the BIM workflow [11-12].

2.4.3Simulation and modeling of the street landscape.

We can visually review and analysis the road landscape engineering. The 3D simulation model can display high definition dynamic data, covering the road scenery of the construction site and the project, such as the construction site, the use of slag, terrain digging and filling, etc., users can query through the simulated mode. On the Navisworks software platform, we constructed a 3D simulation model of the street landscape using CAD technology. The drawn 3D simulation model has the advantages of high resolution, high color accuracy and excellent model details. For those complex shapes that are difficult to be precisely divided, they are decomposed into multiple units and repeatedly modified and edited to get the basic elements. These basic elements are combined according to the spatial structure relationship to form a 3D simulation model of the street landscape. Finally, the model is imported into the Navisworks visualization software, and a 3D simulation image of the street landscape is rendered [13-14].

2.4.4Implementation of the three-dimensional simulation system of street landscape based on BIM.

The main steps of the process of the 3D simulation system based on BIM technology: (1) based on the characteristics of the street landscape in the street landscape project, the 3D simulation model of the street landscape in the design. (2) Import the 3D simulation model completed in step (1) into the Navisworks software platform, and render the dynamic simulation data in the 3D simulation model into a file format readable by the software platform. (3) The secondary development of urban roads using Navisworks software to realize the three-dimensional simulation of urban roads [15-16].

3 Analysis of simulation result

Building visualization is to integrate the architectural design and construction plan on the modeling software platform, set the completion time of each process, and integrate the specific design plan with the system before the start of the building, to establish a 3D and dynamic virtual simulation construction. In the later stage, the function can be freely expanded in the simulation engine according to the application needs [17]. We can see the design idea of architectural visualization from Figure 3. 3D dynamic virtual construction using BIM is an advanced technology, which can provide scientific planning for engineering. We can clearly see the construction starting point and flow direction of each part, so as to better organization and management of construction. Errors and design defects can be identified before submitting a design, and the design review process is no longer limited to experts who can read the drawings or view the model in Revit. Study of building damage assessment through collision detection and the use of physical engines. This technology not only improves the construction efficiency, but also reduces the construction cost and risk. In the traditional construction process, architects and engineers often need to rely on experience and intuition to choose construction skills and technical measures. However, the 3D dynamic virtual construction with BIM can select excellent construction skills and corresponding technical measures more efficiently. By simulating the construction process, we can predict the potential problems and risks, and take corresponding measures to solve them in time [18].

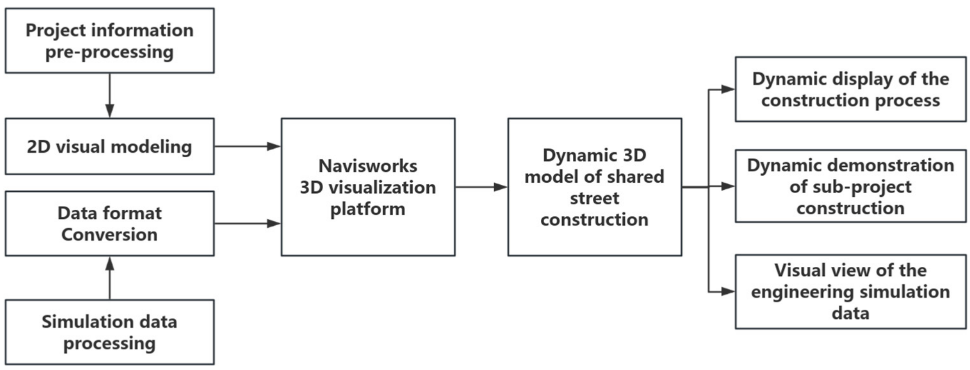

Figure 3. Implementation scheme of street landscape 3D simulation system of BIM technology.

4 Conclusion

The BIM technology is used to efficiently plan and analyze the materials, construction progress and cost of the shared street, and to count the construction path in real time to ensure the statistical accuracy of the project quantity. BIM technology can shorten the budget estimate period of highway engineering project and improve the budget estimate accuracy. BIM technology is applied to the urban public space planning system, which can realize the collaborative work of all departments and improve the efficiency and efficiency of block shared design. Combined with BIM, Internet of Things, GIS and other technologies, the BIM operation and maintenance management platform is built to provide a complete BIM operation and maintenance management system for the urban public transportation and water supply system. BIM technology is applied to the common street design, which can optimize the road design of all stages, improve the quality and efficiency, control the project scale and cost, and realize the whole-process management. At the same time, it provides various decision-making references for decision-makers.

Acknowledgments: This work was financially supported by the key project of Sichuan Private Education Association in 2023 "Digital Transformation Path of Environmental Art Design in the Background of Informatization" (No.MBXH23ZD4).

References

[1] FUKUDA S, BERNARD A, GURUMOORTHY B, et al. (2014). Product lifecycle management for a global market. Springer.

[2] Zhu Zijun, Zhang Yulong, Cui Lingling, et al. (2017). Design and implementation of three-dimensional simulation system for large architectural landscape based on BIM technology. Modern Electronics Technology, 40 (04): 111-114 + 119.

[3] Zhao Heng. (2023). Experimental study on light reduction of vegetation landscape outside highway tunnel based on 3D BIM modeling. Transportation World (18): 4-7.

[4] LOVE P E D, SIMPSON I, HILL A, et al. (2013). From justification to evaluation: Building information modeling for asset owners. Automation in construction, 35: 208-216.

[5] ZHANG S, TEIZER J, LEE J K, et al. (2013). Building information modeling (BIM) and safety: automatic safety checking of construction models and schedules. Automation in construction, 29(4): 183-195.

[6] Chen Yueping. (2019). Simulation of intelligent identification method of high difference features of urban street landscape. Computer Simulation, 36 (11): 331-334 + 418.

[7] Marancy. (2020). Design of the landscape simulation system for virtual 3D Vision technology. Modern Electronic Technology, 43 (23): 15-19.

[8] Li Chang, Wang Hui. (2020). Construction of urban landscape simulation system under virtual reality technology. Modern Electronic Technology, 43 (20): 175-178.

[9] Zhang Yinyu. (2021). Application of BIM visual simulation system for water supply commissioning in sewage treatment plant. Water supply and drainage in China, 37 (14): 69-72.

[10] MIETTINEN R, PAAVOLA S. (2014). Beyond the BIM utopia: Approaches to the development and implementation of building information modeling. Automation in construction, 43 (7): 84-91.

[11] Yang Shan, Feng Ze, Meng Xuemin, et al. (2019). Practice and research of virtual simulation information technology of GIS / BIM system. Science and Technology Innovation and Application, (36): 70-71.

[12] Zhu Zijun, Zhang Yulong, Cui Lingling, et al. (2017). Design and implementation of 3D simulation system based on BIM technology. Modern Electronics Technology, 40 (04): 111-114 + 119.

[13] LOVE P E D, MATTHEWS J, SIMPSON I, et al. (2014). A benefits realization management building information modeling framework for asset owners. Automation in construction, 37: 1-10.

[14] Shi Qingwei, Pang Yongshi, Jiang Yuhan. (2016). Simulation of building construction safety risk early warning and decision model based on system dynamics and BIM. Journal of Civil Engineering and Management, 33 (02): 83-89.
[15] Wu Shabing, Xu Ying. (2021). Development of historical building digital display platform and simulation experience system based on BIM —— Take Zhai Accord Museum as an example. Engineering construction and Design (21): 132-134 + 137.
[16] Wang Hui, Dong Wenpeng, Fang Xiaofeng. (2021). Research and development and application of construction simulation system for foundation pit engineering based on BIM. Journal of Applied Technology, 21 (02): 179-184.
[17] Zhang Shengnan, Yue Haonan, Chen Wenkun. (2019). Research on the virtual simulation and stress of building electromechanical system based on BIM technology. Tianjin Science and Technology, 46 (03): 47-49 + 53.
[18] Wang Ge, Zhou Chaoyang, Yang Xiaodong. (2019). Design and implementation of a 3D simulation system based on BIM. Gansu Science and Technology, 35 (04): 19-22.