www.cadanda.com Computer-Aided Design AND APPLICATIONS

CAD Rendering of City Square Landscape Design of Virtual Reality Scene

Junli Zhang[1] and Qian Sun[2]

[1]School of Humanities and Arts, Shanghai Lixin University of Accounting and Finance, Shanghai 201209, China, 20129005@lixin.edu.cn
[2]Shanghai Pudong Planning & Architecture Design Co., Ltd., Shanghai 200120, China, sam_sunqian@163.com

Corresponding author: Junli Zhang, 20129005@lixin.edu.cn

Abstract. Urban square landscape construction has important value in urban development, environmental protection, aesthetic appreciation and so on. The introduction of computer aided technology to promote the digital transformation of landscape planning and design can further improve the efficiency and quality of planning and design. The urban square landscape design and planning project is taken as the main body of the study. Specific design and analysis were carried out for the experimental platform construction, three-dimensional object realization and urban square landscape design model construction scheme, and AHP was used to establish a virtual reality urban square landscape design evaluation model. The final evaluation results show that using computer technology and software can complete the construction of virtual reality scene with high efficiency, accuracy and quality. Based on the evaluation model of city square landscape design and integration of CAD rendering technology, the three-dimensional city square landscape design simulation system designed in this paper closely integrates. production of domestic plant database, suitable for city square landscape terrain design, parametric design of city square ancillary facilities, etc., well meet the needs of professional designers, fully fill the blank of domestic city square professional software.

Keywords: Computer Aided; City Square Landscape Design; Cad Rendering
DOI: https://doi.org/10.14733/cadaps.2023.S11.1-12

1 INTRODUCTION

The current information age, the application field and depth of various computer technologies have been expanding continuously. The traditional planning and design mode of landscape city square drawn by two-dimensional plane drawings has been gradually transformed to the direction of digital design, and the application of VR technology has become the main direction of development in this field. In urban square landscape planning and design, it is mainly applied to CAD, GIS, VR and other computer-aided technologies, among which VR technology has significant application advantages in

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

virtual reality scene construction rate, picture quality, ease of landscape element insertion, real-time acquisition and human-computer interaction interface functionality, so it has become a popular technology in this field at present. Byun and Sohn [1] believe that in computer-aided urban square design, three-dimensional modeling is first necessary, using modeling software such as AutoCAD and SolidWorks. Modeling software provides rich modeling tools and methods that can be customized and modified according to user needs, thereby quickly and accurately constructing a three-dimensional model of the square. In computer-aided urban square design, material parameter presetting can help designers quickly and accurately select materials and carry out subsequent processing and manufacturing processes. Visual simulation can help designers predict the appearance and performance of squares, thereby optimizing the design and manufacturing process. Optimizing design can help designers optimize the structure, composition, and performance of squares, thereby improving the performance and quality of products. Fakhry et al. [2] use various CAD software such as SolidWorks, AutoCAD, MASTERCAM, etc. to design and manufacture squares, including steps such as material parameter presetting, visual simulation, and optimization design. In short, computer-aided urban square design can help designers quickly and accurately design and manufacture urban squares, thereby improving product performance and quality. Jiang and Zhang [3] believe that the application of visualization technology in landscape design is becoming increasingly widespread. 3D visualization can collect data resources through technical means such as GIS, BIM, and the Internet of Things, and combine the operation and maintenance management, emergency command, and other business systems of the park. By overlaying the business data of each system in a virtual scene, a visualized digital twin park can be established to achieve visual management while providing decision support. 3D visualization can also be used for planning and construction, integrating 3D spatial information from the perspective of planning management. Visualize and display the planned spatial information, and evaluate and compare the planning schemes. Realize panoramic browsing and display of planning schemes, and conduct sunlight analysis and visibility analysis of planning schemes based on three-dimensional space, providing clear and clear visualization scenes and intuitive and accurate analysis results for leadership decision-making and the public. In addition, 3D visualization technology can also be used for operation and maintenance management and emergency command. Kerr and Lawson [4] outlined the development of the AR prototype "Time Master", which aims to educate first-year students and non designers on the fundamental principles of landscape architecture. This study examines the learning potential and benefits of AR technology, with a focus on new practices for creating digital stories in situational experiences. Rodríguez et al. [5] analyzed the application of 3D visualization technology in landscape design, which can achieve visual management while providing decision support, improve design efficiency and quality, and provide customers with a better experience. The application of virtual reality technology in coastal landscape design is receiving increasing attention. Virtual reality technology can present elements such as coastline, beaches, tides, and marine life in virtual spaces by establishing three-dimensional models, providing designers with intuitive design references and inspiration. Virtual reality technology can also allow designers and visitors to interact in virtual spaces through interactive means, such as simulating natural phenomena such as waves and winds, allowing visitors to have a deeper understanding of the characteristics and evolution process of coastal landscapes. In addition, virtual reality technology can also simulate different coastal landforms and ecological environments through virtual reality modeling technology, providing designers with more comprehensive design references. The application of virtual reality technology in coastal landscape design can not only improve design efficiency and quality, but also provide customers with a better sense of experience. Designers can use virtual reality technology to display coastal landscapes more intuitively and vividly, allowing visitors to have a deeper understanding of the characteristics and evolution process of coastal landscapes, thereby better meeting the needs of customers.

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

2 RELATED CONCEPTS

In view of the above problems, we propose to study the three-dimensional model technology of city square landscape. This technology applies advanced CAD technology, which will solve the landscape design of city square more perfect, so as to improve the work efficiency and design level of city square landscape bidding and scheme design. Specifically, in order to study the effective connection mechanism between computer-aided technology and landscape planning and design work, this paper adopts computer-aided technology to explore the digital design of landscape planning, briefly introduces the structural framework of computer-aided technology, the design idea of node level and the design process of LOD level detail algorithm, and takes the urban square landscape design and planning project as the research subject. Wang [6] analyzed the use of virtual reality technology for coastal landscape design. At the same time, the parameterized design methods of new images in landscape design were analyzed, and the landscape design of coastal areas using virtual reality technology was analyzed. Willis et al. [7] enabling them to adapt to machine learning methods. Finally, the performance of the system is verified, and the verification results show that the designed system well meets the needs of professional designers. Foreign computer aided technology appeared earlier, the development is relatively fast, in industry, aerospace, military, education and other fields have a wide range of applications. In the field of planning and design, the use of architectural design, industrial design, urban planning has been very mature, and a set of very standardized procedures and standards. Wu et al. [8] analyzed that CAD virtual landscape refers to the simulation of real natural landscape and buildings in CAD software. For designers and architects to design and manufacture. CAD virtual landscape can conduct 3D modeling of natural landscape and buildings through computer modeling software such as SolidWorks, AutoCAD, etc. The application of CAD virtual landscape by Yang et al. [9] can help designers and architects more intuitively understand the characteristics and evolution process of natural landscape and buildings, so as to better design and manufacture. For example, CAD virtual landscape can be used for architectural design and planning. Through virtual reality technology, it can simulate the real natural landscape and buildings, providing designers and architects with a more comprehensive design reference. CAD virtual landscapes can also be used for urban planning and design. Yang and Yang [10] use virtual reality technology to establish three-dimensional models of cities, providing more intuitive design references for urban planning and design. In addition, CAD virtual landscape can also be used for landscape design and planning. Through virtual reality technology, it can simulate the real natural landscape and buildings, providing designers with a more comprehensive design reference. Zalilov et al. [11] concluded that CAD virtual landscapes are an important design tool that can help designers and architects design and manufacture more intuitively and vividly, thereby improving design efficiency and quality, and providing customers with a better experience. The traditional three-dimensional garden landscape construction and virtual display have problems such as inflexible landscape spatial organization. Zhao [12] comprehensively utilized 3D CAD to organize and showcase the entire process. It has established a three-dimensional digital terrain model of the garden and a real-time fluctuation model of the garden water body.

3 THREE-DIMENSIONAL LANDSCAPE DESIGN OF CITY SQUARE BASED ON COMPUTER AIDED TECHNOLOGY

3.1 Overall System Framework

The system reads various types of files through the data acquisition module of landscape design and stores the basic materials required by landscape design in the resource library. Completed landscape model scene design through 3D modeling and 3D texture rendering; The data statistics module uses the user desktop component to realize landscape data statistics. As shown in Figure 1.

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

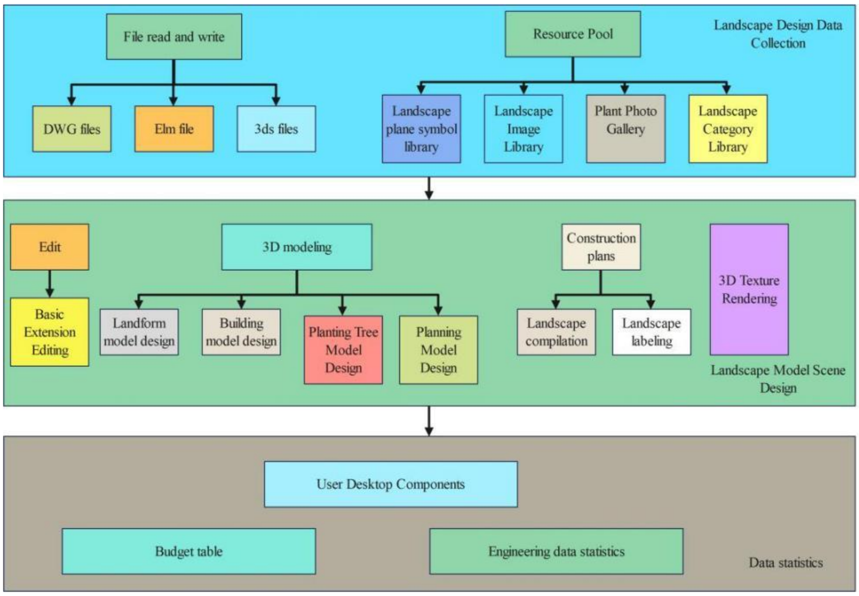

Figure 1: Overall structure of urban square landscape design system.

The content of construction drawings includes field survey of city square landscape design project, CAD drawing of city square landscape design project (city square landscape design plan, construction drawing diagram, plant configuration diagram, public facilities distribution diagram, lighting design drawing, water supply and drainage drawing, construction drawing description, drawing catalog, etc.). The project CAD drawing skill menu of city square landscape design can be subdivided into: Square field survey, square survey drawing CAD processing, square function zoning, square boundary CAD drawing, square terrain CAD drawing, square road CAD drawing, square pavement CAD drawing, square water body CAD drawing, square sculpture sketch CAD drawing, square general plan drawing, square construction layout drawing, square plant configuration CAD drawing, square public A total of facilities CAD drawing, square construction drawing description, square construction drawing exchange, etc.

3.2 Landscape Model Scene Design Module

Three-dimensional modeling is the core of landscape model scene design module, mainly responsible for geomorphic model, building model, planting tree model, planning model design. According to the model design results, the construction drawings were drawn, the landscape model scenes were compiled and marked, and the landscape optimization was realized through three-dimensional texture rendering.

Three-dimensional landscape design adopts the physical organization structure of tree nodes, and uses nodal distribution to realize the construction of each element. In texture rendering, can be carried out by node as a unit, easy to operate. The tree node structure can also display information in detail. When the landscape is adjusted and modified, it does not need to abandon the whole design, but only needs to be carried out for a certain node, which greatly increases the design flexibility. By integrating the Tree Engine into the system, the rendering construction of planted trees is realized, and its rendering flow chart is shown in Figure 2.

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

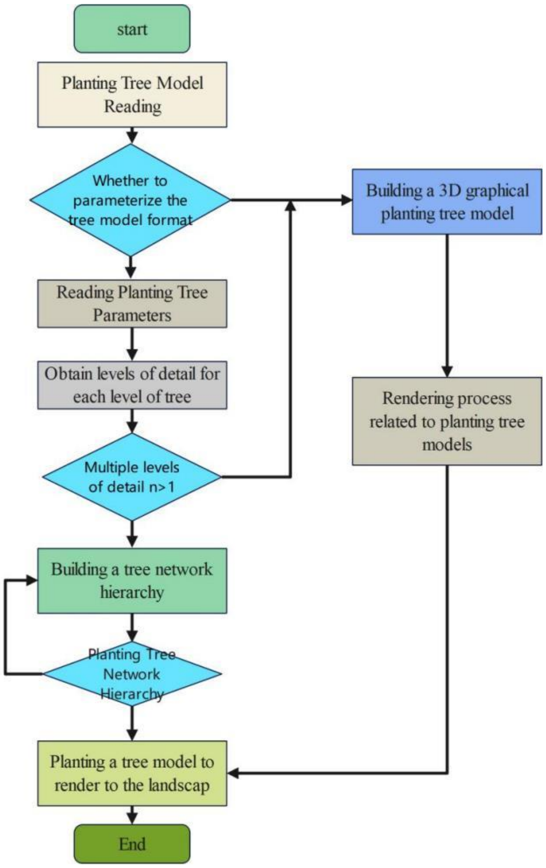

Figure 2: Rendering process of planting tree model loading scene.

When using VR technology to construct virtual reality scenes, it is necessary to measure the roughness of the grid and strike a balance between eliminating cracks and refreshing rate. Set the mediation threshold as C2 and the grid roughness as DHmax. If and only if the following conditions are met, the grid will continue to be divided; otherwise, it will not be divided:

$$\frac{1}{\max(DH_{\max},1)} < C_2 \tag{1}$$

According to the visual principle of human eyes, C1 is set as an adjustable threshold combined with the rendering condition, the distance between human eyes and the grid center is l, and the grid side length is defined as:

$$\frac{1}{d} < C_1 \tag{2}$$

By combining the above two formulas, the judgment criteria for grid division can be generated. The formula is as follows:

$$\frac{1}{d \times C_1 \times \max(DH_{\max},1) \times C_2} < 1 \tag{3}$$

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

When two adjacent grids show differences in the number of partition times, it is necessary to judge the elimination conditions of triangular cracks 3. The shortest distance from the intersection point of the horizontal and vertical viewpoints to the secondary grid is set as d. In order to prevent cracks, it should meet the following requirements:

$$\frac{1}{2}\left(1+\frac{d^2-d_2^2}{d^2+d_2^2}\right)<\frac{DH^2{}_{\max 2}}{DH^2{}_{\max 1}}<1 \tag{4}$$

$$l_2^2=d^2+\frac{d_1^2}{l_1^2}=d^2+d_2^2 \tag{5}$$

$$\begin{bmatrix} x_1 \\ y_2 \\ z_1 \\ 1 \end{bmatrix}=\begin{bmatrix} 1 & 0 & 0 & \mathrm{t} \\ 0 & 1 & 0 & \mathrm{t}_y \\ 0 & 0 & 1 & \mathrm{t}_z \\ 0 & 0 & 0 & 0 \end{bmatrix}.\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \tag{6}$$

In the formula, the horizontal, vertical and vertical coordinates before the transformation are x, y and z, which are respectively added with the translation vector and are the translated coordinates. The horizontal, vertical and vertical coordinates after the transformation are x1, y1 and z1. For the contraction transformation and rotation transformation of matrix, the coordinates before the transformation can be multiplied by the transformation matrix to obtain the coordinates after the transformation. The original point coordinates plus the translation vector equals the translated point coordinates. 2) Construct the scaling transformation matrix represented by S, described by [x,y,z,1], set ft=(Pt1,Pt2... ,PtNj), the homogeneous coordinates of Pti at any pixel point, and its scaling transformation matrix is calculated as shown in Equation (7):

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix}=\begin{bmatrix} \mathrm{s}_x & 0 & 0 & 0 \\ 0 & \mathrm{s}_\mathrm{y} & 0 & 0 \\ 0 & 0 & \mathrm{s}_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \tag{7}$$

3)The rotating local coordinate system overlapped with the global coordinate system, and the rotation transformation matrix was constructed to compare the directions of pixels in different Spaces. The rotation transformation matrix is calculated as shown in Equation (8):

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix}=\begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ \cos\theta & \sin\theta & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \tag{8}$$

In the scale transformation and rotation transformation matrix, the original point coordinates are multiplied by the transformation matrix to obtain the transformed pixel point coordinates. Geomorphic model design is a combination of digital orthophoto superposition and digital terrain model (DEM) to generate ground landscape design. The main modeling methods of geomorphic model design are as follows:

The surface modeling method of regular network (DEM) uses some terrain points distributed equidistant in the direction of horizontal and vertical coordinates to generate rectangular grid. Pij

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

represents the plane coordinates of any point through I, J representing the column number of grid matrix and the basic information in the DEM file.

$$\begin{cases} X = X_0 + J.D_x \\ X = Y_0 + J.D_y \end{cases} \tag{9}$$

It is suitable for all data structures and is not affected by sampling methods. Contour method is adopted to complete the modeling. Surface modeling of Triangulation Irregulars (TIN) approximates topographic surfaces by using continuous triangular planes formed by irregularly distributed discrete data points.

3.3 Building Model Design

Shepard's method is the simplest "inverse weight" interpolation method.

$$F(x, y) = \sum_{i=1}^{n} \omega_i f_i \tag{10}$$

n: The number of points around the perimeter of (x,y) to define its z value.

$$\omega_i = \frac{h_i^{-p}}{\sum_{j=1}^{n} h_j^{-p}} \tag{11}$$

$$Z = \frac{\sum_{i=1}^{n} \frac{1}{(D_i)^p} Z_i}{\sum_{i=1}^{n} \frac{1}{(D_i)^p}} \tag{12}$$

P: Index, usually set to 2.

hi: distance between the interpolation point and the known point i.

$$h_i = \sqrt{(x - x_i)^2 + (y - y_i)^2} \tag{13}$$

or

$$h_i = \sqrt{(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2} \tag{14}$$

$$\omega_i = \frac{\left[\frac{R - h_i}{Rh_i}\right]^2}{\sum_{j=1}^{n} \left[\frac{R - h_j}{Rh_j}\right]^2} \tag{15}$$

hi: distance between interpolation point and known point i.

R: distance between the insertion point and the farthest point.

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

4 RESULTS AND ANALYSIS

4.1 Experimental Verification

Function test and contrast test are carried out on this system respectively. Function test is to check the operation of each function module of the system. As for comparative test, this system is compared with the monocular vision 3D reconstruction system and the virtual simulation technology based 3D situation display system in the control test, from three aspects of system response time, image effect and design cost.

Test each function of the system. For the file reading and writing module, test whether it can normally read all kinds of file information and whether it can collect basic data; For the basic database of landscape data such as resource database, landscape plane symbol database, landscape picture database, plant picture database and landscape category database, it is necessary to test whether the data can be stored effectively and whether the stored data can be extracted and applied normally. For editing module, it needs to test its basic extension function. For the 3D modeling module, test the design effect of various landscape models; For building, landform, planting trees model design module, test construction function; It also tests the 3D planning capability of the planning model design, as well as the landscape design effect of the construction drawings and the optimization effect of 3D texture rendering. Finally test and display the cost budget and statistical data information for the project.

4.2 Result Analysis

Three systems are used to design the three - dimensional landscape of a square scene. In order to avoid the chance, test 20 times, and then calculate the average, all functions can run normally, proving that the system function is good, stable operation, can be applied to the landscape design industry.

Landscape design was carried out for 6 residential areas respectively, and the design cost is shown in Figure 3. As can be seen from the figure, the cost of three-dimensional situation display system is in the middle, nearly twice that of the system designed in this paper, and the design cost of three-dimensional reconstruction system is the highest. When the number of landscape design is 1, the cost difference is nearly 6 times that of the system designed in this paper, up to 60,000 yuan. The system designed in this paper has low cost and great market value.

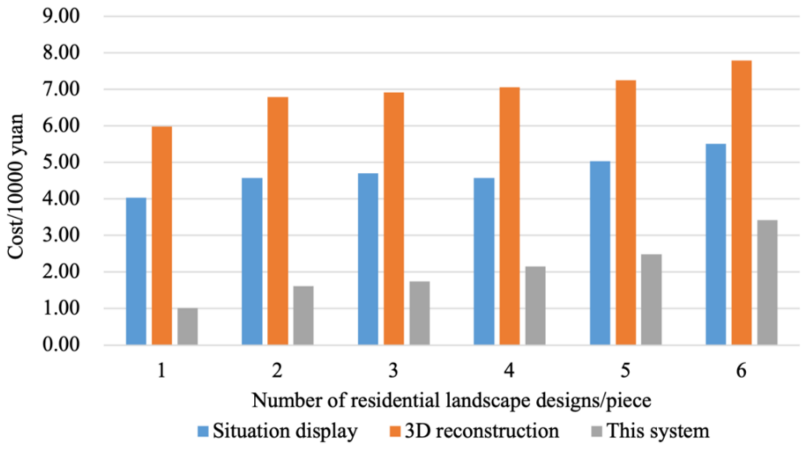

Figure 3: Design costs of residential landscape projects of the three systems.

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

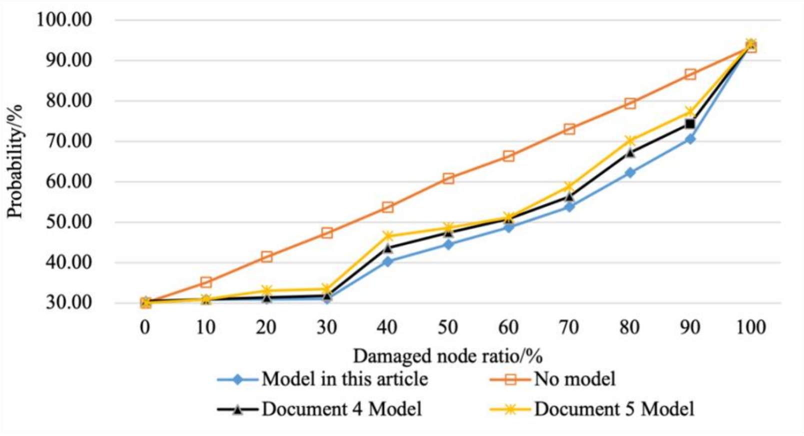

Figure 4: The damaged node becomes the cluster head.

Figure 4 illustrates the damaged node becoming the cluster head. According to the characteristics of the system, LoadRunner is selected as a test tool to test the performance of the system through load testing. By simulating the system load under the load conditions of the actual software system and constantly loading the transaction occurrence times, the response time of the system and CPU resources occupied by the system under different loads are observed to test the system performance. If you look at Figure 5. As can be seen from the figure, the time response of transaction operation showed an upward trend with the increase of load. However, with the increase of rendering volume, the response time did not exceed 5 seconds, which was within the acceptable range.

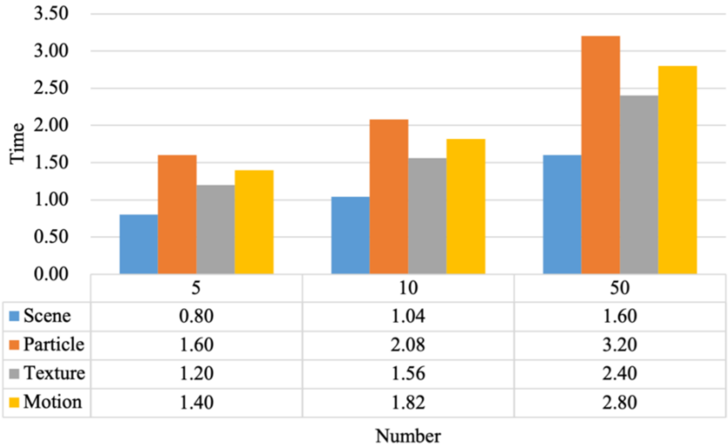

Figure 5: Average response time of load tests in mixed scenarios.

The network performance of the system access mode is simulated by Matlab, and the relationship between network throughput S and traffic G under ALOHA access mode is shown in Figure 6. It can be seen that ALOHA access mode has better performance and lower complexity when the traffic

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

volume is low and the number of nodes is small. With the increase of the amount of data transmitted in the communication network, the probability of communication data conflict on the wireless channel will increase significantly, and the overall communication performance of the network will further decline until the throughput will decline significantly after reaching a certain point. In extreme cases, they can't even communicate properly.

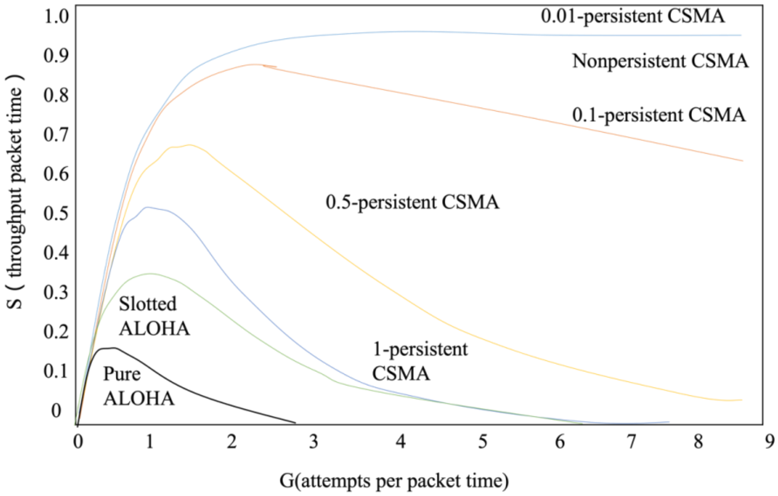

Figure 6: System network throughput.

In order to test the import performance of the designed urban square landscape module, this paper, aiming at the topographic data of the three urban square blocks with the sizes of 1025×1025, 2049×2049 and 4097×4097, respectively, carried out a survey based on MPI-GD, MPI-L-BFGS and Liblinear (base).

That is, the experiment of the improved and simplified vision importing strategy (referred to as the improved method) proposed in this paper. In the experiment, the change of the number of triangles before and after importing and the time consuming of importing are recorded, as shown in Figure 7.

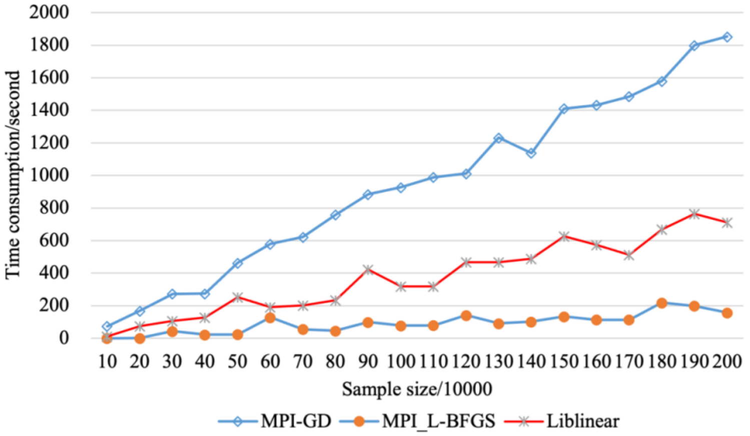

Figure 7: Relationship between terrain block size and import time.

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

5 CONCLUSION

The concept of modern landscape is all-encompassing, including almost all places where people carry out activities, and landscape is not only a place for people to watch, we can also use it to improve climate conditions, regulate the temperature, humidity and air flow in local areas, use it to protect the environment, control water pollution and soil pollution. In a word, compared with any previous era, modern landscape design has a broader scope, more colorful content, more complex facilities and more powerful functions. In addition, landscape design needs to anticipate the design effect to facilitate modification, so it needs the help of computer-aided design technology. In general, by applying computer technology to landscape planning and design of scenic city square, referring to CAD drawing and 3D modeling results, using standard design process and programming methods to complete the overall structure design of the planning project, and using SketchUp platform and computer-aided technology to complete the construction of scene system. It provides users with more independent and active choice opportunities, and effectively improves the intuitive feeling and experience of urban landscape planning and design. Finally, the system performance is tested and compared, and the results show that the constructed system has competitive ability.

Junli Zhang, https://orcid.org/0000-0002-0558-3386
Qian Sun, https://orcid.org/0000-0002-9409-8381

REFERENCES

[1] Byun, Y.; Sohn, B.-S.: ABGS: A system for the automatic generation of building information models from two-dimensional CAD drawings, Sustainability, 12(17), 2020, 6713. https://doi.org/10.3390/su12176713
[2] Fakhry, M.; Kamel, I.; Abdelaal, A.: CAD using preference compared to hand drafting in architectural working drawings coursework, Ain Shams Engineering Journal, 12(3), 2021, 3331-3338. https://doi.org/10.1016/j.asej.2021.01.016
[3] Jiang, W.; Zhang, Y.: Application of 3D visualization in landscape design teaching, International Journal of Emerging Technologies in Learning (Online), 14(6), 2019, 53. https://doi.org/10.3991/ijet.v14i06.10156
[4] Kerr, J.; Lawson, G.: Augmented reality in design education: Landscape architecture studies as AR experience, International Journal of Art & Design Education, 39(1), 2019, 6-21. https://doi.org/10.1111/jade.12227
[5] Rodríguez, M.-M.; Sánchez, A.-L.-J.; Maté, G.-M.-Á.; Muñoz, N.-Á.-L.; Gonzalez, A.-D.: Comprehensive generation of historical construction CAD models from data provided by a wearable mobile mapping system: A case study of the Church of Adanero (Ávila, Spain), Sensors, 22(8), 2022, 2922. https://doi.org/10.3390/s22082922
[6] Wang, H.: Landscape design of coastal area based on virtual reality technology and intelligent algorithm, Journal of Intelligent & Fuzzy Systems, 37(5), 2019, 5955-5963. https://doi.org/10.3233/JIFS-179177
[7] Willis, K.-D.-D.; Pu, Y.; Luo, J.; Chu, H.; Du, T.; Lambourne, J.-G.; Matusik, W.: Fusion 360 gallery: A dataset and environment for programmatic cad construction from human design sequences, ACM Transactions on Graphics (TOG), 40(4), 2021, 1-24. https://doi.org/10.1145/3450626.3459818
[8] Wu, H.; Gui, Z.; Yang, Z.: Geospatial big data for urban planning and urban management, Geo-spatial Information Science, 23(4), 2020, 273-274. https://doi.org/10.1080/10095020.2020.1854981
[9] Yang, B.; Liu, B.; Zhu, D.; Zhang, B.; Wang, Z.; Lei, K.: Semiautomatic structural BIM-model generation methodology using CAD construction drawings, Journal of Computing in Civil Engineering, 34(3), 2020, 04020006. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000885

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

[10] Yang, S.; Yang, J.: Application prospect of CAD-SketchUp-PS integrated software technology in landscape planning and design, Computer-Aided Design and Applications, 18(S3), 2020, 153-163. https://doi.org/10.14733/cadaps.2021.S3.153-163

[11] Zalilov, R.; Reshetnikova, E.; Savelyeva, I.; Svistunova, E.; Rebezov, M.; Goncharov, A.; Odinokova, E.: CAD systems and computer graphics in the training of specialists in the field of mechanical engineering, Journal of Critical Reviews, 7(2), 2020, 162. https://doi.org/10.31838/jcr.07.02.30

[12] Zhao, X.: Application of 3D CAD in landscape architecture design and optimization of hierarchical details, Computer-Aided Design and Applications, 18(S1), 2020, 120-132. https://doi.org/10.14733/cadaps.2021.S1.120-132

© 2023 CAD Solutions, LLC, http://www.cad-journal.net