Multi-platform Interactive System of Sustainable Residential Building Design

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Abstract. With the continuous development of the economy, the process of urban construction in China is also accelerating, and construction enterprises are facing unprecedented development opportunities. The rapid economic development has made the ecological environment continue to deteriorate, and sustainable residential buildings conform to social development. Sustainable residential buildings are the best architectural design suitable for people's survival and ecological development by using ecological knowledge to organically combine the elements of nature, architecture and people. Firstly, this paper summarizes the sustainable residential buildings, analyzes the design principles of sustainable residential buildings, and studies the design methods of ecological residential buildings. Then use the Auto CAD platform for development and research, build a multi-platform interactive system based on the standard atlas of the main components commonly used in residential buildings, establish the three-dimensional model of the main building components using the modeling method consistent with the user's habits, combine the parametric formal research method and digital construction technology, display a research idea of technology integration, and provide a method for the realization of the building interactive system. Ensure the consistency and correctness of data, standardize the sustainable residential building design work, improve the reuse rate of building design documents, improve the compilation efficiency of building design, control and improve the quality of building design documents.

Keywords: Residential Building Design; Sustainable Development; Auto Cad; Multi-Platform Interaction.
DOI: https://doi.org/10.14733/cadaps.2023.S8.124-134

1 INTRODUCTION

The emergence of ecological architectural design concept has added new vitality to China's construction industry [1]. Building sustainable ecological buildings has important strategic value for long-term planning and design [2]. Only by fully applying and popularizing the design principles

of ecological architecture in China's modern architecture can we realize the continuous development of ecological architecture in China and accelerate the process of ecological environment construction in China. Therefore, we should speed up the construction of ecological buildings, so that the ecological environment can achieve long-term and stable development, and let people have a healthy living environment. In the design of modern ecological residential buildings [3].

Sustainable development should be combined with the natural environment. In the design of modern ecological residential buildings, if we want to achieve sustainable development, we can not copy a certain construction design model at will [4]. We should combine the actual situation of the local natural environment and study the relevant characteristics of the local natural environment in depth. During the period of ecological building design, not only should the environment be used scientifically, but also the serious negative impact of building construction on the natural environment should be minimized. On the basis of comprehensive consideration of the natural environment characteristics of the building design site, the environment outside the building design site should also be considered [5]. Due to the relatively vast territory of China, the relevant natural environment, including the geographical environment, has diversified characteristics and is relatively complex in terms of climate conditions. Therefore, in China's ecological architecture design work, it is not suitable to carry out a relatively single architectural design model, and it is necessary to integrate the architectural design work into the overall system connected with the natural environment. Make the construction project gradually become an important part of the natural ecosystem, minimize the damage of construction to various landscapes, rocks and vegetation in the natural system, and realize the harmony and unity between the architectural design and the natural environment. Vigorously develop various ecological architectural design models that coordinate with the natural environment and coexist with nature, and promote the sustainable development of modern ecological residential architectural design.

Urban planning and design, landscape planning and graphics, and architectural layout have undergone gradual adjustment, mainly in the process of landscape planning and drawing. The integration of computer aided planning technology knowledge, parameter control and optimization behavior bring new efficiency, new method and new thinking mode to design. Jia [6] believes that in the sustainable design of cities, the sustainable development of the construction industry has become a benefit challenge that can be created. At present, sustainable design needs to be developed in combination with emerging digital media intelligence. Applying the concept of sustainability to the design of building schemes has gone beyond the connotation of current popular design concepts such as energy-saving building design and green building design. Use computer performance simulation to optimize the building design for comprehensive analysis. Priority should be given to the application of passive climate and site response strategies, so as to achieve the architectural design in a realistic context. At the beginning of the scheme design, a scientific evaluation of the climate and geographical environment of the building's construction environment is carried out to better carry out the construction. Liu et al. [7] analyzed the sustainable role of CAD sustainable building information management in coordination. To maintain the sustainability of the building by implementing sustainable operation and maintenance practices. Further improve and maintain the indoor environmental quality (IEQ). Buildings can choose sustainable or recyclable materials, especially those that have an impact on the environment, such as steel. Sun et al. [8] believes that it is necessary to understand the appearance and function of the building before construction. Therefore, BIM enables architects to make necessary decisions to improve the sustainability and accuracy of buildings. Buildings with LEED certification are one of the most sustainable structures on the earth. The sustainability of the construction industry does not only mean the choice of recycled wood or recycled steel. Each time the contractor starts the engine on a heavy equipment, the project will increase the scale of its carbon footprint. Taking these certifications into account during design can make the final evaluation process more direct and time-saving. Once the design is completed and introduced to the contractor, BIM can help improve the efficiency of the construction phase. This improvement can take various forms, from the BIM-driven robot layout system to the introduction of

prefabricated construction methods to reduce the time required to complete the construction project. Velykodniy [9] introduced the final results of scientific research on the development of open system models and methods for automated design, as well as the construction technology of building engineering. The purpose of the research is to systematize the results of the integration of reusable components. These results are accumulated by developers in a certain period of time during the development of departmental CAD systems, and are used to update the software structure of existing resources. Zhao [10] uses 3D CAD and virtual landscape research parameters to drive the integrated construction, organization and display of the entire sustainable landscape design process. Fresnel dynamic optical reflection effect of water body based on light direction is realized. Through scene clipping and level of detail model technology, the rendering efficiency and real-time rendering of landscape are improved.

This paper mainly studies, analyzes and studies sustainable residential building design, and uses AutoCAD technology to develop a multi-platform interactive system with complete functions, safety and reliability, efficient operation, flexible use and convenient maintenance. The system can quickly and conveniently create building components, intelligently edit and modify models, and automatically generate two-dimensional horizontal and vertical sections to meet the requirements of high-performance and data consistency access in technology, while ensuring its security. Being able to become an independent architecture professional design software and participate in multi-disciplinary 3D collaborative design work as a major design discipline is a beneficial attempt for the design, construction and operation stages of China's process plants, promoting the progress of engineering informatization and playing a demonstration role.

2 RELEVANT CONCEPTS AND THEORETICAL BASIS

2.1 Overview of Architectural Design and Sustainable Development

With the increasing voice of ecological environment protection, the broad masses of people are deeply thinking and changing the concept of ecological architecture, actively exploring the integration of architectural design and natural environment, and realizing ecological architectural design. The concept of ecological architecture design was first put forward in 1969, and the American architect put forward it for the first time in his works, which also marks the birth of relevant ecological architecture to a certain extent. The main purpose of ecological architectural design is to apply the basic principles of ecology and relevant ecological determinants to the field of architectural design, so as to effectively solve the problem of ecological and environmental integration in human architectural design, to improve the living environment of the masses of people to a certain extent, and to achieve economic development benefits in the process of ecological architectural design Optimization of comprehensive benefits among social development benefits and environmental protection benefits.

The concept of sustainable development was first put forward in the 1980s. It mainly means that on the basis of meeting the development needs of modern people, it can not harm the interests of future generations. It can also be said that it is to achieve coordinated progress among economic development, social development, resource protection and environmental protection in the development of modern economy. The sustainable development in the field of architectural design, to some extent, refers to the organic combination of our immediate practical interests and the relative long-term interests of the entire social development on the basis of comprehensive consideration of environmental factors, urban development factors and architectural design factors. Combine the local development interests of each region with the comprehensive interests of the world development, so as to realize the fair and reasonable scientific sharing of the current earth resources. In addition, we should minimize the waste of resources and the pollution of the ecological environment to ensure the long-term survival and development of human society.

2.2 Overview of Auto CAD System Development Platform

Now, with AutoCAD as the platform, there are various secondary development and design software for the architectural design industry. The commonly used and famous ones are Tianzheng series, Explorer series and Hongye series.

DWG is a drawing saving format created by AutoCAD, and has become the standard format of 2D CAD. Many other CAD also directly use dwg as the default working file in order to be compatible with AutoCAD. The Dwg file can be modified arbitrarily in the relevant CAD software. The dwg file is a binary file, which is mainly divided into six parts according to the address offset: the locator part, the image part, the environment variable part, the class definition part, the entity part, and the object mapping part. These six parts point to each other and jointly express the complex logical relationship of entities in the dwg file. Therefore, dwg files can be edited using the secondary development program on the AutoCAD platform. Each dwg file is the result of the designer's painstaking efforts. It has happened that Party A took the full set of dwg drawings of the yard and went to the yard to directly change the drawing sign and draw the drawing.

DWF is an open and secure file format developed by Autodesk. It has the same layers and linetypes as dwg, which can be measured and plotted. However, dwf is read-only and cannot be edited, so it is very safe. For this system, only advanced users can download dwg files from the archived server, and ordinary users can only download dwf files for browsing and learning.

Unlike the previous AutoCAD secondary development tools AutoLISP and ADS, ObjectARX applications are a set of DLLs (dynamic link libraries).

The core of ObjectARX is two sets of key APIs, namely Ac Db (Auto CAD database) and Ac Ed (Auto CAD compiler). In addition, there are other important library components, such as Ac RX (Auto CAD real-time extension), Ac Gi (Auto CAD graphics interface), Ac Ge (Auto CAD geometry library), and ADSRX (AutoCAD development system real-time extension). ObjectARX can also load applications as needed; Using ObjectARX for application development can also integrate with Windows system at the same level and realize interactive operation with other Windows applications. Therefore, the execution speed of functions programmed with ARX has been greatly improved. ARX class library adopts the packaging form of standard C++class library, which also greatly improves the reliability and efficiency of programmer programming.

The program compiled with ARX is in the same code area with ACAD after loading, sharing all data areas, and can directly do any operation on the data inside CAD, so it has high execution efficiency and powerful functions. Even though the AutoCAD series software itself has completed the basic functions of the program, a large number of other internal commands are actually implemented with ARX. At the same time, the program compiled by ARX has wide compatibility. For the domestic CAD platform Haochen CAD, which is widely used in China, its source code can be directly used to compile the GRX program of Haochen CAD.

2.3 Concept of Multi-Platform Interactive System

Architectural design is usually carried out in two stages: preliminary design and construction drawing design. For large architectural projects, schematic design should be carried out before the preliminary design; For small construction projects, schematic design can be used to replace the preliminary design documents. For large projects with complex technology, the technical design stage can be increased. Pre-design preparation mainly includes familiarization with the design assignment, collection of basic design data and investigation and research.

The preliminary design is the document for the design unit to select the scheme, the competent department to approve the project, and the basis for the technical design and construction drawing design. The main task of the preliminary design is to propose the design scheme. That is, according to the requirements of the design assignment and the collected basic data, combined with the site environment, taking into account the technical and economic conditions and the requirements of the architectural art, make reasonable arrangements for the overall layout and space combination of the building, and propose two or more plans for the

construction unit to choose. On the basis of the selected scheme, it will be further improved and integrated into a more ideal scheme, and the preliminary design document will be drawn up for the approval of the competent department. Construction drawing design is the final stage of architectural design and the design document submitted to the construction unit for construction. It must be designed according to the preliminary design (or technical design) approved by the superior competent department.

The main modules of the system include the creation of projects, grids, 3D building models, view generation, drawing layout and other modules. This paper mainly studies the use of IFC standards to store building component model information, display 3D visualization, and support the editing operation through CAD commands. Its associated components can be intelligently linked. After the design of the model is completed, it can quickly and automatically generate horizontal and vertical sections according to the 3D model, It also provides labeling and other functions. The system provides an overall scheme from design modeling to drawing, and the establishment of 3D model can provide accurate data model for designers to do various professional collaboration and collision inspection in the later stage. The specific modules of the system are shown in Figure 1.

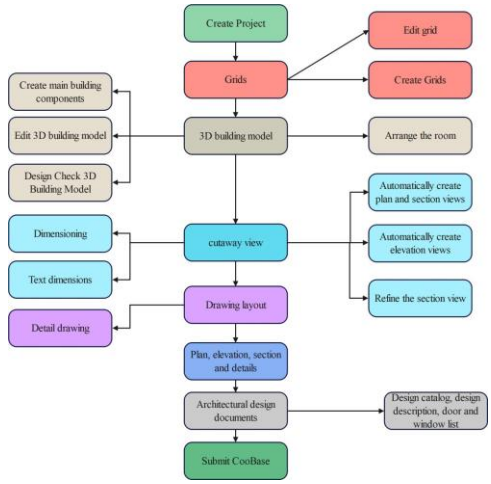

Figure 1: Module structure of multi-platform interactive system.

3 RELATED TECHNOLOGIES

3.1 Parametric Description of AutoCAD

AutoCAD is a flagship product developed by AutoDesk, and also has relatively complete 3D solid functions. Its core is ACIS modeling technology, which is a world-class geometric modeling platform. According to the above two guiding principles, for parameterization of any geometric model, we first list the corresponding constraint equations, then solve the number of parameters, and determine the type of corresponding parameters. In combination with the dimensional constraint relationship between graphic elements and graphic dimensions, we can list the following constraint equations. There are five constraint equations in total, and the matrix equations are listed accordingly:

$$\mathbf{A}_{5\times 14}\,\mathbf{X}_{14\times 1}=\mathbf{0}_{5\times 1} \tag{1}$$

Where A5 × 14 is the coefficient matrix, X14 × 1 is an unknown vector; At this time, the coefficient matrix A5 of the equation group can be obtained through MATLab × Rank of 14:

$$Rank\left(\mathbf{A}_{5\times 14}\right)=5 \tag{2}$$

Therefore, we can make the following definition: geometry

$$\text{Geometry}=\left\{\text{Entity}^{1}\left(x_1, x_2, \cdots, x_n\right)\right\} \tag{3}$$

Where m represents the number of parameters parameterized by geometry; N indicates that the geometry is generated by n sub-voxels; Entityi (x1, x2,..., xm) represents the modeling process of the ith voxel; It is a four-tuple consisting of four parts of modeling and construction process:

$$\text{Entity}^{1}\left(x_1, x_2, \cdots, x_n\right)=\left\{\text{ClosePolyline}\left(x_1, x_2, \cdots, x_n\right)\right. \tag{4}$$

Obviously, this is an iterative evaluation process of sequential operation. According to the traversal order of CSG, the established process can be stored in a process description file Geometry.proc in turn.

3.2 3D Graphic Transformation

$$T=\begin{bmatrix} abcp \\ defq \\ hijr \\ lmns \end{bmatrix} \tag{5}$$

Coordinate transformation mainly uses the plane four-parameter model to realize the transformation from source coordinates to target coordinates. The plane four-parameter model is a similar transformation model, which includes two coordinate translation parameters △ x/△ y, one scale parameter m, and one angular rotation parameter α, The transformation relationship is shown in formula (6).

$$x_k = \Delta x + a x_j - b y_j \tag{6}$$

Where (xj, yj) is the source coordinate before conversion, (xk, yk) is the target coordinate after conversion, a=mcos α, b =msin α. The calculation method of coordinate transformation is simple. The target coordinates can be calculated by bringing the four parameters and source coordinates into equation (6). In order to improve the user experience, the user only needs to select the conversion area, source coordinate name, and target coordinate name. The program automatically calls the conversion parameters by index according to the user's choice to realize the automatic conversion of coordinates. The coordinate conversion process is shown in Figure 2.

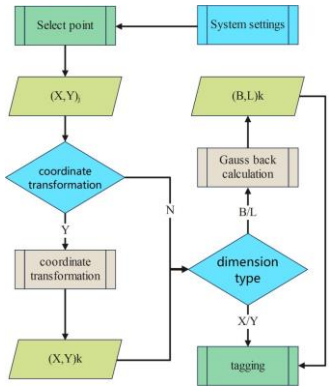

Figure 2: Coordinate conversion process.

To ensure that the conversion parameters are not leaked, the conversion parameters are invisible to users, and the conversion parameters are encrypted and stored in the dongle. Identify by the unique hardware ID of the dongle to ensure that the labeling program corresponds to the dongle. At the same time, the encryption and decryption of the conversion parameters are realized by using the public key and private key of the RSA asymmetric algorithm that comes with the encryption dog. In order to reduce the accuracy of coordinate conversion, the code of coordinate confusion and coordinate conversion can be 'transplanted' into the dongle, greatly improving the confidentiality. When the marked coordinates are geographical coordinates, it is necessary to convert the rectangular coordinates (x, y) of the Gauss projection plane into geodetic coordinates (B, L) by Gauss inverse calculation, and then mark them. Generally, the iterative method is used:

$$y_{\mathrm{k}} = \Delta x + bx_{\mathrm{j}} + ay_{\mathrm{j}} \tag{7}$$

3.3 Parametric Modeling Technology of Buildings

If the quantization unit index of the carrier data c is p and the information to be embedded is 1, the algorithm first looks for the first quantization unit in the current range of the data and the first quantization unit in the right range (counting from 0), and according to the different sizes of p and k, selects the quantization unit nearest to point c to complete the data embedding, and obtains the data c after embedding information.

Similarly, given a carrier data c represented by a floating point number, the information to be embedded w, where w {0,1,..., k □ 1}. The information embedding process is described as follows:

Step 1: First, calculate the quantization unit index p of the current data c as

$$p = \frac{c - \dfrac{c}{kl} \times kl}{l} \tag{8}$$

Step 2: According to the distance between the quantization unit p and the quantization unit w where the data is located, the embedded information is

$$c' = \begin{cases} c + (w - p) \times 1 \\ c + (w - p + k) \times 1 \\ c + (w - p - k) \times 1 \end{cases} \tag{9}$$

Similarly, according to formula (9) and c, complete the information extraction. In addition, because the algorithm is not reversible, the recovered data cannot be obtained. In addition, according to formula (9), in the case of uniform distribution of two-dimensional vertices, the maximum distortion of the algorithm is less than or equal, which is expressed as

$$\max D = | k / 2 | \times l \tag{10}$$

Given a carrier data f, and interval length is R. Basis information:

$$w \in \left\{0, 1, 2, \ldots, 2^{s} - 1\right\} \tag{11}$$

S, the calculated interval of f is

$$p = f / R \times 2^{S} - f / R \times 2^{S} \tag{12}$$

As

$$r = (f - f / R \times R) \tag{13}$$

$$d_{0} = (f / R + 1) \times R + w \times R / 2^{s} + r / \left(3 * 2^{s}\right) - f \tag{14}$$

$$d_1 = \left| f / R \times R + (w + m/3) \times R / 2^S + r / \left(3^* 2^S\right) - f \right| \quad (15)$$

4 EXPERIMENTAL RESULTS AND ANALYSIS

4.1 Performance and Quality Attribute Analysis

Select the commonly used building software Tianzheng Software and the large software Revit Architecture that supports BIM for comparative analysis. Tianzheng Building is also an architectural design auxiliary software developed based on the extension of the AutoCAD graphics platform. It defines the main components of the building and has certain building information model functions, but does not have integrated storage and management functions for building information. Revit Architecture is an architectural design software released by Autodesk that supports BIM technology. Its 3D model editing function is powerful, the parameters of components and models are detailed, and the requirements for hardware equipment are high, as shown in Figure 3.

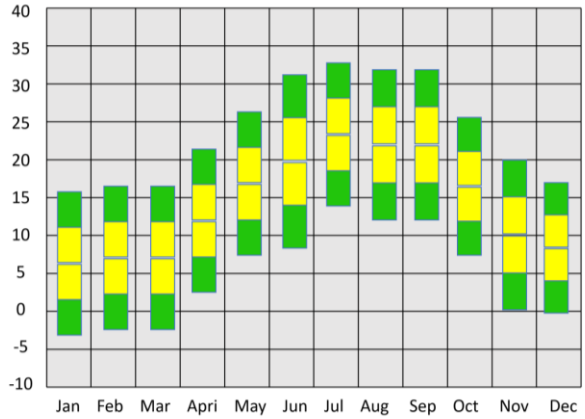

Figure 3: Performance comparison of architectural design software.

As shown in Figure 3, from the comparative analysis of the performance of three architectural design software, it is shown that the lightweight BIM architectural design system based on AutoCAD has the characteristics of low equipment requirements and supporting two-dimensional and three-dimensional operations compared with the two-dimensional architectural design software, and also has the characteristics of supporting the model generation view of BIM technology software, integrated storage of architectural information, and strong consistency of drawing information.

4.2 Reversibility Analysis

According to the algorithm principle, for any embedded vertex iv in the vertex set, in the information embedding stage, first of all, iv is obtained by transforming to the new coordinate system, the dense vertex siv is obtained by information iw, and the siv is obtained by transforming to the original coordinate system. In the information extraction stage, the siv is obtained by transforming the coordinate system. Because it is reciprocal, si is established. After that, the siv was restored to iv. According to the above analysis, iv was always valid.

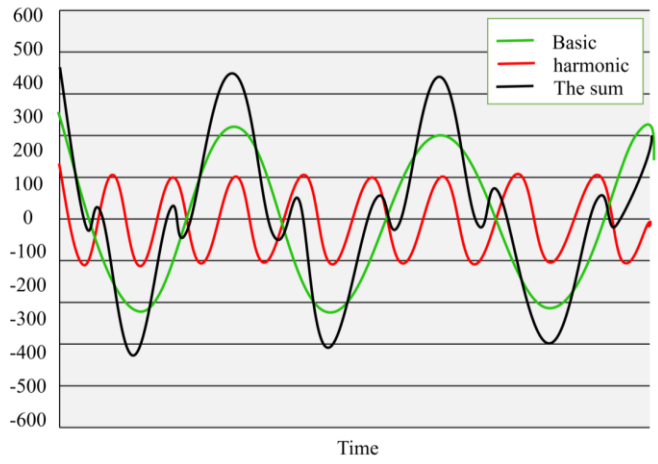

Figure 4: Analysis of distortion of restoration engineering graphics.

To verify the reversibility of the algorithm, the distortion of the restored CAD engineering graphics is calculated according to the original CAD engineering graphics. Figure 4 shows the average distance between the original engineering drawing and the restored engineering drawing is less than 10-13, and the maximum distance is less than 10-12. Similar to the principle, the algorithm is reversible.

Figure 5 shows the average embedding capacity of this algorithm on 300 graphics is 2.8209, slightly higher than the existing algorithms.

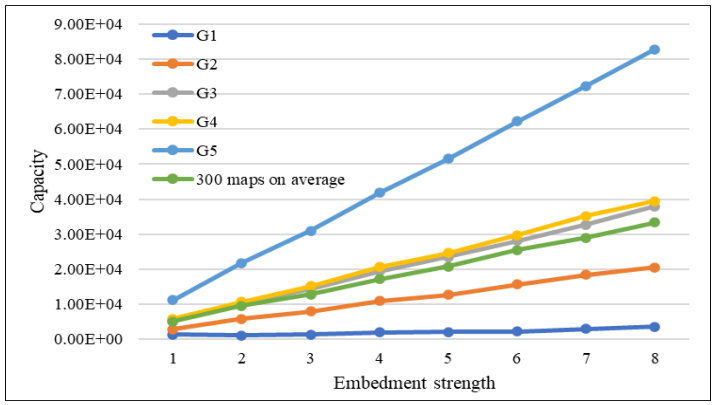

Figure 5: Relationship between capacity and embedding strength s.

In order to verify the above assumptions, the semi-vulnerability analysis of the dense graph after the RST transformation and reordering operation was carried out. The corresponding operations include scaling (scaling factor 0.1, 1.2, 2.6 "), rotation (rotation angle 1, 60, 270), {((1 9.47), (5. 34.6}), RST combination and vertex reverse order. Figure 6 shows the proposed algorithm can resist the overall geometric transformation, namely RST operation, but cannot resist the reordering operation of vertices.

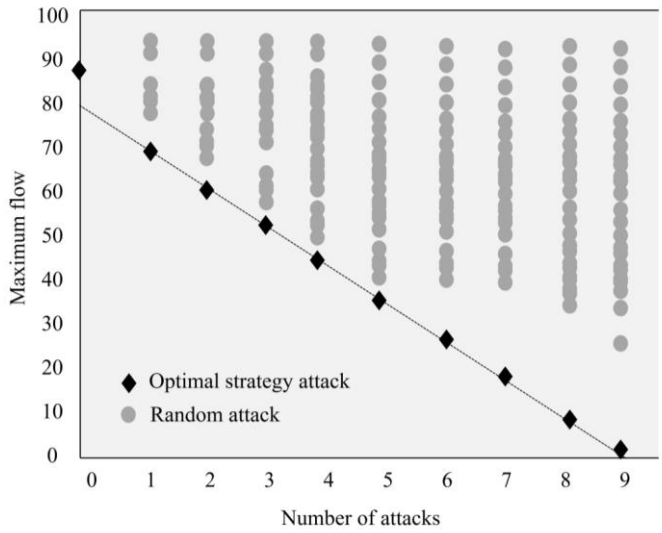

Figure 6: Semi-vulnerability analysis (NC).

But embeds secret information by modifying the coordinates of vertices, so this kind of algorithm can have good anti-steganalysis ability for this steganalysis algorithm. The feature is considered as a significant anomaly feature, that is, containing secret information. The experiment compares the anti-steganography analysis ability, as shown in Figure 7.

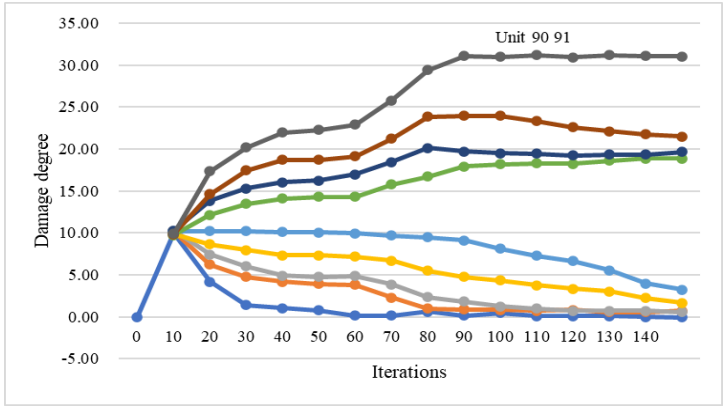

Figure 7: Analysis of statistical characteristics before and after embedding different methods.

Figure 7 shows that after embedding the information using existing IQIM-A, VC, NV, RN and other algorithms, the statistical characteristic values of all the encrypted graphics are greater than 0.0169, that is, embedding the information using these algorithms can be detected by the hidden information detection model in, while embedding the information using the algorithm in this chapter will not change the statistical characteristic values of the graphics, and will not exceed the threshold of 0.0169. To sum up, compared with the existing algorithms, the anti-steganalysis ability of CAD algorithms is better.

5 CONCLUSION

Because of the popularity of CAD technology, it is easier for people to accept the architectural design system based on AutoCAD platform. At the same time, BIM integrates construction project information with 3D model, which has the characteristics of parameterization, object-oriented modeling and interactivity, and is an advanced concept. Combined with the practice of architectural design, this paper has carried out the development practice of lightweight BIM architectural design system based on AutoCAD, and verified the reliability and practicability of the system through the test of design examples. To sum up, realizing the sustainable development of modern ecological residential building design is a work with high difficulty. The sustainable development of ecological building design is related to the healthy development of the construction industry and affects the living environment of the masses. Therefore, in the design process of ecological buildings, we should comprehensively consider various factors, correctly understand the basic connotation of ecological buildings and sustainable development, and improve the building materials and construction technology to fundamentally ensure the sustainable development of ecological residential building design.

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