Paradigm Academic Press
Art and Society
ISSN 2709-9830
JUN. 2025 VOL.4, NO.5

Research on the Application of Digital Modeling in Inheriting Traditional Chinese Architectural Art — Taking the Design of the Lei Family Architecture as an Example

Weisha Liang[1]

[1] Changchun University of Science and Technology, Jilin, China

Correspondence: Weisha Liang, Changchun University of Science and Technology, Jilin, China.

doi:10.63593/AS.2709-9830.2025.06.005

Abstract

With the progress of science and technology, digital modeling technology plays an increasingly important role in the protection and restoration of traditional architectural heritage. This paper discusses the application of digital modeling technology in the inheritance of Chinese traditional architectural art, especially taking the architectural design of style Lei family as an example, and analyzes how technology supports the preservation and revival of traditional architectural art. By using modern design software such as 3DMAX, Maya, rhinoceros and SketchUp, this study discussed in detail the specific application and effect of these tools in the digital modeling, restoration and display of style ray family buildings. The paper also examines the contribution of digital modeling technology to the restoration of architectural details, the reconstruction of historical data, public display and education promotion.

Keywords: digital modeling, traditional architectural art, style mine building, restoration and inheritance

1. Introduction

As an important representative of traditional Chinese architectural art in the long history of Chinese architectural art, the architectural art of the Shiyilei family carries a rich cultural and historical heritage. However, with the passage of time, precious architectural heritage such as the architectural art of the Shiyilei family faces challenges such as natural aging, environmental changes, and human destruction. This makes the protection, inheritance, and innovation of traditional architectural art an urgent issue that needs to be addressed. In recent years, the protection and restoration of traditional architectural heritage, as well as the rapid advancement of digital modeling technology, have provided many new solutions. These technologies can not only efficiently record and restore the details of buildings but also enhance public awareness and support for cultural heritage. At the same time, they can strengthen interactive experiences with the public through virtual displays (Wang Gang, Li Hao, Lei Xin & Cheng Shiyu, 2018).

This paper will delve into the application of digital modeling technology in the inheritance of traditional Chinese architectural art, taking the architecture of the Shiyilei family as an example, and analyze how to achieve this through modern design software such as 3DMAX, MAYA, Rhinoceros, and SketchUp.

2. Basic Application and Advantages of Digital Modeling Technology

In recent years, digital modeling has developed relatively well and has been widely applied. The mainstream two-dimensional drawing software packages include CAD (Computer Aided Design), which stands for computer-aided design. People can engage in traditional architectural plane restoration work through computer programs and hardware devices. Based on CAD, there are many secondary developments such as Tianzheng CAD (Cui Xiao, 2017) and so on. In terms of three-dimensional modeling, there are 3DMAX, MAYA,

Rhinoceros, Sketchup, and so on.

3DMAX is a powerful 3D modeling and rendering software developed by Autodesk, which is widely used in architectural visualization, industrial design and other fields. It can build a complete architectural scene, including the surrounding environment, landscape elements and urban background, so as to improve the overall visual effect. The software is helpful to understand the spatial relationship of traditional buildings and their surrounding environment.

Maya is usually famous for its powerful animation and special effects production ability, but it is also unique in construction. Combined with virtual reality (VR) technology, Maya creates complex animation and interactive scenes to provide an immersive architectural experience. At the same time, the display of complex structure and construction details of the process details and construction difficulties of traditional buildings can help understand the artistic difficulties of traditional buildings.

RHINOCEROS (RHINO) is a high-precision modeling software widely used in the architectural field for its accurate surface modeling capabilities and flexible plugin ecosystem. Its Chinese name is also translated as "犀牛". It primarily works in conjunction with digital fabrication techniques, such as 3D printing and CNC machining, to prepare precise architectural models through collaborative efforts, and enables the visualization of complex traditional architecture through 3D printing.

SketchUp is famous for its intuitive, easy-to-use and rapid modeling capabilities, especially suitable for building visualization and the restoration of early traditional buildings.

Table 1.

Software name	Main application fields	Core advantages
3DMAX	High quality building visualization and building roaming	Powerful rendering ability, animation roaming production
MAYA	Advanced animation and virtual reality, complex surface modeling	Parametric modeling
RHINO	Precise parametric modeling, integration with BIM system, and joint work with 3D printing technology	High precision modeling, multi technology cooperation application
SKETCHUP	Sketch modeling, rapid modeling	Intuitive and easy to operate

The adoption of Computer-Aided Design (CAD), 3D scanning, and modeling software has significantly enhanced the efficiency and precision of traditional architectural art restoration. Traditional buildings often feature complex structures and intricate decorations, making manual restoration both time-consuming and labor-intensive, and prone to errors during construction. Digital modeling, on the other hand, can rapidly generate high-precision 3D models that accurately capture architectural details and proportions, reducing human errors. Furthermore, digital data can be easily stored, modified, and shared, enabling more efficient collaborative restoration efforts among multiple parties. Designers and restoration experts can evaluate restoration plans in advance through virtual simulation and optimize the restoration path before implementation, thereby improving the overall quality of the restoration.

3. Application of Digital Modeling in Inheriting Traditional Architectural Art

3.1 Application of Digital Protection Technology

Digital preservation aims to comprehensively and accurately record and archive the existing architectural heritage through digital technology, so as to facilitate future research, display and protection.

Digital preservation technology involves the use of high-precision 3D scanning and modeling to produce detailed digital models. For instance, laser scanning (such as LIDAR) and photogrammetry techniques are employed to conduct high-precision 3D scanning of buildings, generating comprehensive architectural models that encompass geometric architectural information and simultaneously document architectural details such as texture, color, and material. The comprehensive digitization of large-scale architectural sites can be facilitated through aerial photography using drones, combined with laser scanning. In complex environments, LIDAR technology can provide depth information, which is difficult to obtain through conventional manual measurements, while photogrammetry complements the detailed surface texture. The integration of these two techniques significantly enhances the overall means of architectural art preservation.

Establish a unified digital archive to store all digital building data. These archives are not only convenient for information retrieval and sharing, but also can be used as long-term digital records to prevent physical damage

caused by natural disasters, wars or other reasons.

3.2 Application of Heritage Restoration Technology

Design software such as 3DMAX, MAYA, Rhinoceros (Rhinoceros), and Sketchup (SketchUp) have played a significant role in the restoration of traditional architectural heritage. By providing efficient 3D modeling, visualization, and animation capabilities, these software programs preserve and perpetuate architectural art. Each of these software programs possesses unique features, greatly enhancing the precision and efficiency of restoration work.

Through 3DMAX, designers can create a detailed three-dimensional model based on simulating real building materials and lighting effects, thereby producing vivid renderings. This is of great significance for formulating restoration plans, conducting subsequent restoration design evaluations, and presenting the restoration results to relevant personnel. In addition, the animation function of 3DMAX can be used to simulate changes in buildings over different time periods, helping the restoration team better understand and plan the restoration process.

Restoration experts can utilize MAYA to create virtual roaming animations of buildings, allowing for a comparison between the historical evolution of the buildings and their condition before and after restoration. This, in turn, aids in the optimization of restoration plans. Furthermore, this interactive display method enhances public awareness and support for cultural heritage conservation. The excellent compatibility of MAYA with other design software also facilitates smoother collaboration among multiple departments. Consequently, MAYA plays a pivotal role in the field of cultural heritage conservation.

Rhinoceros supports a highly customized modeling process and can accurately copy the complex curves and decorative details of traditional buildings. At the same time, with the help of its plug-in grasshopper, designers can realize parametric design and automatic modeling, and improve work efficiency and model accuracy. In addition, the high-precision 3D model generated by rhinoceros can be used for the design and sales of architectural and cultural peripheral products (such as memorial models, decorations and educational materials), and further promote the dissemination and commercialization of cultural heritage. More importantly, rhinoceros can seamlessly integrate with 3D printing technology. Designers can directly convert digital models into solid models for display, research or repair work. For example, through 3D printing, complex architectural details and decorations can be accurately copied to ensure the degree of detail restoration in the repair process. Through joint work with 3D printing technology, it can also be used to make physical models of buildings to help the repair team more intuitively understand and plan the repair scheme.

SketchUp is suitable for the initial repair and concept stages. Designers can quickly create the basic structural model of the building, and compare and adjust the schemes. Its intuitive operation mode reduces the technical threshold, enabling team members from different backgrounds to easily participate in the process of building modeling and repair design.

3.3 The Specific Path of Carrying Forward the Traditional Architectural Art

Virtual reality (VR) and augmented reality (AR) are good means to apply digital models to virtual display and interactive experience, so as to enter the public view. Visitors and researchers can “visit” inaccessible or fragile architectural sites through VR devices, which not only protects physical buildings, but also provides an immersive experience. The audience can experience the historical style and cultural connotation of traditional buildings without visiting the scene. The interaction between traditional architectural art and the public has been realized, so that traditional architectural art can appear in the exhibition hall in the form of virtual reality, enter the public’s vision, and the whole people can actively participate in the protection of architectural cultural heritage. Digital modeling provides powerful technical support for the virtual restoration and display of traditional buildings. These precious cultural heritage can be presented to the public in a new way.

Through this technology, while expanding the influence of traditional architecture, it also contributes to the preservation and inheritance of traditional architectural art. At the same time, virtual reality (VR) and augmented reality (AR) can assist scholars in gaining a deeper understanding of architectural structures and historical backgrounds, serving educational and research purposes. In terms of the visualization of digital models, it makes the entire process of restoring traditional architectural art more transparent, enhancing public recognition and support for conservation efforts.

4. Style Mine Architecture and Digital Modeling Technology

4.1 Overview of Style ‘Ray Family’

In the early Qing Dynasty, Lei Fada, renowned for his superb architectural skills, and his cousin Lei Faxuan were recruited to Beijing to construct royal palaces. Due to Lei Fada’s meritorious contributions in building the Taihe Hall, Emperor Kangxi bestowed upon him the title of Chief Architect of the Ministry of Works. From then on, Lei Fada was hailed as “Shi Yang Lei” (Pattern Lei). The Shi Yang Lei family flourished during the

mid-to-late Qing Dynasty. Lei Fada participated in numerous royal architectural renovation projects, thus establishing the Shi Yang Lei family's status in royal architectural design. Over eight generations of the Shi Yang Lei family, they gradually became the backbone of royal architectural design, participating in the design and construction of buildings such as the Forbidden City, Temple of Heaven, Summer Palace, and Old Summer Palace. The establishment of the "Shi Yang Lei Drawings" by the Shi Yang Lei family serves as an important document for understanding the artistic design of traditional Chinese architecture, systematically expressing the architectural design process and standards.

The "style thunder" building is mainly made of wood structure, which is composed of tile, brick, stone and other auxiliary materials. Each building is composed of roof, columns, doors and windows, walls and bases. The main components of the building are columns, beams and purlins (Duan Wei & Zhou Yi, 2022). At the same time, the "style thunder" building has the characteristics of flexibility, seismic resistance and grade. The architectural design of style Lei family not only has high practicability, but also shows rich cultural and artistic value. These buildings reflect the traditional Chinese etiquette and Confucian philosophy, and embody these cultural concepts through architectural forms. For example, in the design of the Forbidden City, people with different identities and grades live in buildings with different sizes and decorative styles, which reflects the strict hierarchy. At the same time, the architectural design of the style Lei family integrates a large number of artistic elements, such as the painted Gallery of the summer palace. Each picture has been carefully designed to show the profound understanding of ancient craftsmen on the natural landscape and cultural stories. These artistic decorations not only enhance the aesthetic value of architecture, but also add profound cultural connotation to architecture.

The Lei architecture, a combination of traditional wood structure and symmetrical design, not only maintains the stability of the wood structure, but also can draw philosophical and aesthetic thinking from the design principles of geomantic omen. Therefore, it also shows the profound connotation and unique aesthetic interest of China's traditional architectural culture, which is widely spread in future architectural styles. Based on the traditional wood structure, relying on the symmetrical design, and supplemented by the ideas of geomantic omen, the Lei style architecture presents the core idea of important symbolic significance and value for Chinese traditional architectural culture on the basis of maintaining its own characteristics.

4.2 Chinese Names of Ancient Architectural Models "烫样"

The "style thunder" architectural drawing file is a kind of material historical data bearing important historical value. The architectural process characteristics it shows not only reflect the actual situation of the design of style houses in the Qing Dynasty, but also have important social value and cultural significance for the study of the history of the Qing Dynasty and the construction of cultural development. At the same time, it also represents the highest achievement of ancient Chinese architectural design. The "style thunder" architectural drawing file includes three parts: the "style thunder" architectural drawing, the hot sample and the document. "Style mine" architectural drawings include "style mine" construction engineering planning drawings, design drawings, mapping drawings, construction drawings, as built drawings, decoration drawings and other aspects.

Some of the patterns left by "style thunder" are hot samples, which are architectural models. Hot sample is a three-dimensional drawing of ancient architectural construction, which plays a role of specimen in ancient architectural construction. In ancient times, large-scale construction projects were mainly constructed according to hot samples, including budget, material preparation and construction. "Style thunder" is named for its hot samples. All hot samples of the middle road of the Yuanmingyuan Park are preserved in the construction of the Yuanmingyuan Park. The systematicness, integrity and scale of the "pattern mine" drawings are an important physical specimen of human memory in the field of architecture, highlighting the outstanding wisdom of the "pattern mine" architectural design theory and method. The architectural cultural heritage of "style thunder" is the condensation of the wisdom and labor of the "style thunder" family, and it is a non renewable Chinese cultural heritage (Duan Wei & Zhou Yi, 2022).

4.3 Inheritance, Development and Protection of Style Thunder Architectural Art

In the process of inheriting the architectural art of Shiyilei, the trend of combining traditional craftsmanship with modern technology has become increasingly evident. In particular, the application of 3D modeling technology, coupled with the introduction of new technologies such as virtual reality and augmented reality, has not only broken through the constraints of time and space but also provided a more intuitive understanding and appreciation of the design essence of Shiyilei for both architectural researchers and the general public.

3D modeling provides precise three-dimensional representations of the Forbid-den City architectural complex, allowing researchers to visually access highly accurate data and giving visitors a more vivid and intuitive experience. The widespread application of 3D modeling technology in the Palace Museum has facilitated the acquisition of high-precision architectural data, ensuring the preservation and restoration of every detail of ancient architecture. This is of great significance for both academic research and tourism experiences.

The Old Summer Palace suffered devastating damage in a war, but with the application of digital modeling software such as 3DMAX and Maya, and the 3D virtual reconstruction technology of historical materials, future generations are able to glimpse its once glorious appearance. Additionally, the use of virtual reality technology can provide visitors with an immersive experience of touring the Old Summer Palace, enabling the integration of history and the present across time and space.

Utilizing tools such as Rhinoceros and SketchUp, precise simulations of the architectural layout and spatial structure of the Summer Palace have been conducted, further facilitating research in architecture and landscape art. Coupled with the application of virtual reality technology, remote virtual tours of the Summer Palace have been made possible, allowing more people to personally experience the beauty of its architecture and landscapes. Therefore, beyond the research in architecture and landscape art, virtual reality technology also plays a significant role in enhancing people's aesthetic experiences.

Many tang yang (scale models) face the risk of damage due to material aging or poor preservation conditions, posing a significant threat to valuable cultural heritage. Digital modeling technology, as an effective solution, enables high-precision scanning of tang yang to obtain their three-dimensional (3D) data and form digital archives. Coupled with the assistance of 3D printing technology, researchers can obtain replicas that closely resemble the originals for display and research purposes. Furthermore, augmented reality (AR) technology can integrate tang yang with real-life scenes, allowing viewers to intuitively appreciate the intricate design of these models on mobile devices. The application of digital modeling technology can effectively protect tang yang. The Palace Museum in Beijing conducted LiDAR scanning on the tang yang of the Shiyilei (a type of architectural model), generating high-resolution 3D data models. These models are not only used for digital display but also serve as important reference materials for research and preservation, facilitating the visualization of 3D models and the study of details.

Digital modeling technology has brought new opportunities for the inheritance and preservation of the architectural art of the Shiyilei style. The application of technologies ranging from 3D modeling to virtual reality and augmented reality not only enables the recreation of history but also lays a solid foundation for future research and inheritance (Xie Yang, Zhang Yan & Zhang Yifan, 2012). With the aid of modern technology, the architectural art of the Shiyilei family has breathed new life in the digital era, allowing more people to appreciate the cultural and historical charm behind it, thereby gaining a more comprehensive understanding of it.

5. The Challenge of Traditional Architectural Art Inheritance

Digital modeling technology has brought challenges and opportunities to the inheritance of traditional architectural art. It is inevitable to encounter some bottlenecks when restoring the fine carving and component details in traditional architecture. Especially in the pursuit of accuracy and complexity, modern modeling technology is difficult to meet the requirements of comprehensive display. For example, the original texture and three-dimensional effect of wood and stone carvings in traditional buildings are often missing in digital presentation. Thus, some details of traditional architecture are difficult to be fully displayed in digital modeling technology.

Wood structure is one of the important characteristics of Chinese traditional architecture. It has unique structural mechanical properties, such as tenon joint connection, which is difficult to be fully simulated with the current digital technology. Moreover, due to the natural changes of wood and the influence of temperature and humidity, it is difficult for the digital model to show the real situation. Coupled with the aging and weathering characteristics of wood structure, it is more difficult to simulate its real performance.

Digital modeling requires extensive data collection and processing, particularly high-precision data from 3D scanning, laser mapping, and other techniques. These technologies impose significant demands on equipment and computational resources, resulting in a substantial increase in project costs. Furthermore, the scale and complexity of traditional buildings mean that the data volume of models is extremely large, requiring storage and processing that often exceeds the capacity of general computing devices. The substantial demand for equipment resources and high-precision modeling technology are pressing issues that we currently face.

In the restoration of architectural form, digital technology is very good, but it is often inadequate in the transmission of traditional cultural connotation. Simple technical means are often difficult to convey the symbols, symbolic significance and cultural details in traditional architecture. Digital technology tends to be standardized and simplified, while the cultural connotation of traditional architecture needs fine inheritance, which leads to the gap between technology and culture. How to balance cultural expression and technology is the key issue in the process of digitalization of these buildings.

To sum up, traditional architectural art is facing many challenges in the process of digitalization, such as complexity, material characteristics, resource cost and cultural inheritance. How to break through these bottlenecks and integrate the inheritance and development of digital technology and traditional architectural art

is still an important issue.

6. Conclusion

By discussing the application of digital modeling technology in the style mine architectural art, it is found that the digital modeling technology has certain advantages in restoring complex structures and presenting architectural forms. Through high-precision three-dimensional scanning and modeling, the shape of traditional architectural art can be better preserved. This technology can effectively capture the basic shape, detail components, spatial layout of buildings. It is not only suitable for style thunder buildings, but also can be extended to temples, palaces, residences and other traditional architectural art fields. In the future, digital modeling technology can also carry out special research and develop more accurate modeling methods for different materials, structures and styles, and different traditional building types.

Digital modeling technology can promote the comprehensive inheritance and development of traditional architectural art, and provide more digital support for the protection, restoration and display of these buildings. Of course, there are still some challenges. How to integrate more cultural factors into digital modeling technology and enhance its ability to convey the connotation of traditional culture should be further explored in future research. In developing more intelligent modeling algorithms, while preserving the details of the building structure, taking into account the expression of cultural symbols and historical background, realize the deep integration of technology and culture, and strengthen interdisciplinary cooperation with art, architecture, history and computer technology.

References

Cui Xiao, (2017). Discussion on teaching methods of computer aided design (AutoCAD). *Science and education guide (late)*, (21), 80-81.

Duan Wei, Zhou Yi, (2018). Lei Jingxiu and the Style Lei Drawings Archives. *Journal of Liaoning Technical University (Social Science Edition)*, *20*(06), 94-96.

Duan Wei, Zhou Yi, (2022). Characteristics and cultural inheritance of “style thunder” architectural design. *Journal of Liaoning University of Technology (SOCIAL SCIENCE EDITION)*, *24*(03), 89-91.

Wang Gang, Li Hao, Lei Xin, Cheng Shiyu, (2018). Research on the application of digital technology represented by augmented reality technology in the protection of cultural heritage. *Journal of Hubei Academy of fine arts*, (02), 89-91.

Xie Yang, Zhang Yan, Zhang Yifan, (2012). Design and Implementation of a Virtual Mall Roaming System Based on Virtools. *Journal of Liaoning University of Petroleum and Chemical Technology*, *32*(01), 84-86+94.

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