Intelligent Deduction and Historical Reconstruction an AIGC-Driven Exploration of the Main Hall Ruins at Gonghoulong Temple, Ningde, China

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Abstract

This research explores the innovative application of Artificial Intelligence Generated Content (AIGC) technology in the digital restoration of ancient architectural ruins. It focuses on the unique architectural tradition of Song Dynasty single-bay Buddhist halls in the Changxi River Basin of eastern Fujian, using the Gonghoulong (宫后垄)Temple site in Ningde City, Fujian Province, as a case study. The study pioneers a collaborative research paradigm that integrates architectural archaeology with generative artificial intelligence. Through precise digital surveying and multi-source literature verification, we analyze the spatial organization of stone components at the site, revealing that the Song Dynasty Buddhist Hall at Gonghoulong Temple incorporates layered pavilion concepts, demonstrating distinctive regional characteristics that differ from official architectural practices. By leveraging AIGCpowered intelligent deduction, the study establishes a "digital archiving-intelligent deduction-dynamic intervention" restoration framework through stylized generation and virtual reconstruction simulations. The Gonghoulong Temple site, discovered in the late 20th century, contains significant architectural remains such as house foundations, ash pits, and tombs. The Changxi River Basin preserves numerous Tang-Song period single-bay Buddhist Hall ruins, indicating a unique regional architectural pattern seldom seen in Chinese history. This technological exploration aims to revive the "single-bay pavilion-style" construction wisdom of the Changxi Basin. Through digital analysis and architectural form recombination, it facilitates the virtual restoration of the Song Dynasty Buddhist Hall at Gonghoulong Temple, offering new insights into early Buddhist architecture along China's southeastern coast and establishing standardized references for the intelligent conservation of similar heritage sites across East Asia.

1. Introduction

The Gonghoulong (宫后垄) Temple site, discovered in the late 20th century as a significant historic cultural site in Ningde City (宁德市) (National Cultural Heritage Administration, 2007), contains architectural remains including house foundations, ash pits, and tombs. The Changxi River Basin preserves numerous Tang-Song period single-bay deep-plan Buddhist Hall ruins and stone components, indicating a unique regional architectural pattern rarely seen in Chinese architectural history(Liu, Jiang and Cao, 2021). This research by exploring Artificial Intelligence Generated Content (AIGC) technology in the digital restoration of ancient architectural ruins. Focusing on the unique architectural tradition of Song Dynasty single-bay Buddhist halls in the Changxi River Basin of eastern Fujian, the study employs the Gonghoulong (宫后垄)Temple site in Ningde City, Fujian Province as a case study to pioneer a collaborative research paradigm integrating architectural archaeology with generative artificial intelligence. Through precise digital surveying and multi-source literature verification, we analysed the spatial organization logic embedded in stone components at the site, revealing that the Song Dynasty Buddhist Hall framework at Gonghoulong (宫后垄) Temple, incorporates layered pavilion concepts, demonstrating distinctive regional characteristics that markedly differ from official architectural practices. Leveraging AIGC-powered intelligent deduction, the study establishes a comprehensive "digital archiving-intelligent deduction-dynamic intervention" restoration framework through stylized generation and virtual reconstruction simulations. This technological exploration aims to revive the lost "single-bay pavilion-style" construction wisdom of the Changxi Basin. Through digital analysis and recombination of architectural forms, it facilitates the virtual restoration of the Song Dynasty Buddhist Hall at Gonghoulong (宫后垄) Temple, opening new dimensions for understanding early Buddhist architectural heritage along China's southeastern coast while establishing standardized references for intelligent conservation of similar heritage sites across East Asia.

2. Literature Review and Objectives

2.1 Literature Review

In the field of cultural heritage digital preservation, many worldwide studies have attempted to apply advanced digital technologies to artifact restoration and virtual reconstruction. For example, 3D laser scanning and photogrammetry technologies have been widely used to capture high-precision data of heritage sites and ancient buildings, aiding in the creation of digital 3D models that serve as the digital foundation for restoration(Murphy, McGovern and Pavia, 2009). The development of digital archaeology and interactive technologies has made the "digital immortality" of architectural heritage possible(Bevilacqua *et al.*, 2022). Since 2021, the rise of generative artificial intelligence has brought new ideas for the digital restoration of cultural heritage. AI models have already been applied to restore damaged artworks or precious cultural relics and reconstruct missing parts(Yang, Intan Raihana Ruhaiyem and Zhou, 2025). In the restoration of

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more cultural scenes, deep learning-based image generation models (such as StyleGAN and DALL·E) have been used to recreate historical scenes(Yan *et al.*, 2024). However, AIGC algorithms often lack sufficient domain knowledge when facing specialized restoration tasks for historical buildings, which may lead to discrepancies in historical and archaeological details. Therefore, it is necessary to review the current applications of large language models (LLM) and multimodal generative models in the cultural heritage field, analyze their limitations, and propose a methodology through vertical domain-specific large models to bridge this gap, providing an intelligent technical path for the restoration of historical buildings(Xu, Zhang and Li, 2024).

2.2 Objectives

Considering the delineation, the objective of this study is to elucidate the following three aspects.

2.2.1 Build a Vertical Knowledge Large Model for the Digital Restoration of Song Dynasty Architectural Sites:
This research aims to develop a vertical domain-specific knowledge large model dedicated to the digital restoration of Song Dynasty architectural sites. The model will integrate professional knowledge on the historical background, structural features, and decorative styles of Song Dynasty architecture, along with the AIGC understanding of the architectural principles defined in the book “YingZao Fashi 营造法式”(Pan and He, 2017). It will provide efficient intelligent reasoning and restoration support to ensure the accuracy and historical authenticity of the restoration work. Of course, involvement from professional architectural historians and teams will be necessary to correct and continuously learn from the model’s outputs, which is a key step in the methodology of this study.

2.2.2 Integrating image-text generation models to enhance efficiency and accuracy:
This research aims to promote the industry's active adoption of integrated image-text generation models. By combine deep learning and multimodal technologies, it will achieve the synchronous generation of images and texts for historical building sites. This will significantly enhance the efficiency and accuracy of site restoration, while providing researchers with more intuitive and comprehensive restoration results, thus driving the innovation and application development of digital restoration technologies.

2.2.3 Promoting the standardization and scaling of the restoration of East Asian Buddhist heritage sites:
The most meaningful goal is to promote the standardization of digital restoration for Buddhist heritage sites in East Asia. By establishing unified technical standards and methodological frameworks, combined with advanced AI technologies, this aims to achieve standardized operations for site digital restoration across the region, enhancing the overall efficiency and sustainability of cultural heritage preservation.

3. Site Conditions and Restoration Clues 3.1

Background & Digital Survey

The Gonghoulong(宫后垄)Temple site is in Xiao Shi Village (小石村), Huo Tong Town(霍童镇), Jiao Cheng District(蕉城区), Ningde City(宁德市), and is currently listed as a protected cultural heritage site of Jiao Cheng District. Since the Five Dynasties period under the WuYue Kingdom, Huotong has been a significant Buddhist centre along the southeastern coast of China. The ancient temple of Gonghoulong (宫后垄) was originally built in the fourth year of the Yuan Feng reign of the Song Dynasty (1081 AD), and with a history spanning over 900 years, it bears witness to the region’s long and continuous historical evolution. The site covers an area of 100 square meters, with its orientation facing southeast from the northwest. The site currently has eight existing stone pillars and a Sumeru pedestal (Figure 1). According to the team's digital mapping, the eight stone pillars are 3520 mm in height and are composed of two parts: the base and the shaft, with a diameter of 0.6 meters. The structure has a width of one bay and a depth of three bays. In the centre, there is a stone Sumeru pedestal, which is 0.8 meters high, 3 meters wide, and 2 meters deep. The pedestal has recessed and raised lines and decorations along its four sides. It is arranged in two columns and four rows, creating a layout with one bay in width and three bays in depth. The recessed "凹" (Figure 2) shaped Sumeru pedestal is positioned in the centre of the rear two bays(Ding, Cai and Liu, 2024).


Figure 1. Aerial photo of Gonghoulong Temple

These architectural components are currently well-preserved, still allowing people to appreciate the architectural style and artistic value of the ancient temple(Liu, 2018). The style and carving techniques of the stone pillars and Sumeru pedestal are consistent with other Song Dynasty Buddhist temple remains in the river valley, and they are well-preserved, remaining in their original positions without any disturbance from later generations, making the architectural restoration feasible.

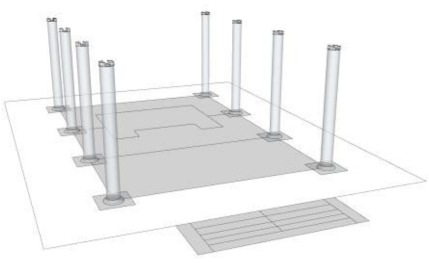
Figure 2. Planning Survey of this site

3.2 Construction Ruler and Spatial Reasoning

The foundation for the digital restoration will be based on field data from digital mapping. The most important clue for restoration comes from the inferred data of the construction CHI (measurement system). The restoration value of the main hall's construction 尺 is 294 mm, which is almost identical to the Tang CHI (295 mm) and smaller than the Northern Song official CHI (310 mm)(Li, 2014). It is speculated that the construction 尺 of the main hall was influenced by the late Tang CHI, and on this basis, there may be a close connection to the formation of local CHI used in Fujian (Table 1).

	Total Width	The First Bay of the Depth	The Second Bay of the Depth	The Third Bay of the Depth	Total Depth
mm	7027	3547	3546	3541	10634
chi	23.901	12.065	12.044	12.010	36.170
Round up	24	12	12	12	36
Rate of coincidence	99.59%	99.46%	99.49%	99.63%	99.53%

Table 1. Reconstruction of the main hall construction ruler of Gonghoulong Temple Site (1 chi 尺 = 294 mm)

Therefore, we define the restoration of the construction CHI for the main hall of the Gonghoulong (宫后垄) Temple site as 1 CHI = 294mm. According to the above table, the main hall construction ruler length is 294 mm, shorter than the Song official ruler 宋官尺 (about 310 mm), which should be because of the use of a Fujian local ruler, as detailed in the analysis below. In this way, the plan composition of the column network can be converted as follows (Figure 3): Width: 24 CHI Depth: 12 + 12 + 12 = 36 CHI At this time, the depth of each bay is divided into two step frames 二步架, thus making the total depth six step frames 六步架. Each frame length 平长 is 36/6 = 6 chi, which is precisely in accordance with the rafter specifications 用椽之制 outlined in Volume Five of the Song Dynasty’s architectural standard “YingZao Fashi 营造法式”
(Pan and He, 2017).

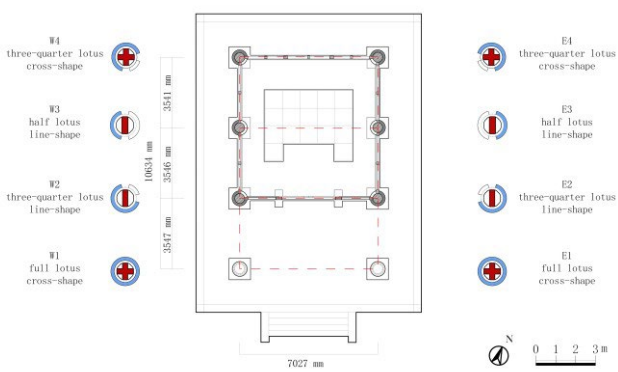

Figure 3. Clues and Diagrammatic Analysis of Site Restoration

4. AIGC- Driven Reconstruction Methodology

This section delineates the AI-driven reconstruction workflow (Figure 5), which uniquely integrates a retrieval-augmented large-model compatible multimodal knowledge base, constraintbased 3D modeling, and generative AI processes. The research methodology will commence with the acquisition of highprecision digital documentation of the ruins, employing laser scans and photogrammetry techniques, to generate millimeterresolution point clouds of the extant columns and the Sumeru pedestal. These data comprise the geometric core of a structured knowledge repository. This repository is enriched with archaeological plans, historical texts (e.g., Yingzao Fashi 营造法式), and images of Song-dynasty Buddhist halls, thus creating a multimodal knowledge base that integrates geometry, semantics, and imagery. This domain-specific database serves as a standardized reference for the site and related monuments, enabling the AI to retrieve precise architectural rules during reconstruction. In effect, the workflow establishes a "from remains to structure, to form, to description" reasoning chain, simulating expert analysis but automating it via AI.

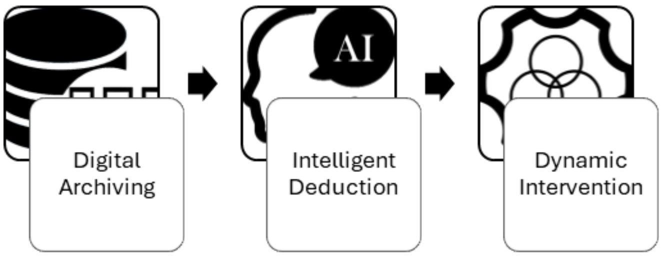

Figure 4. The proposed restoration framework

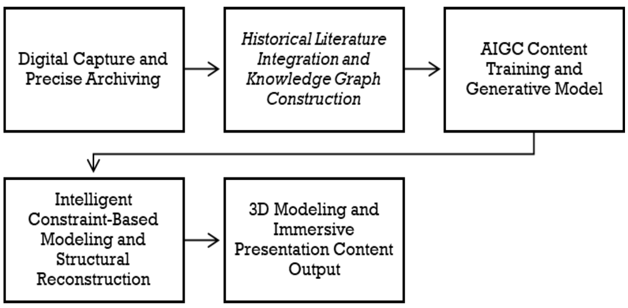

Figure 5. The proposed technical workflow

4.1 Knowledge Graph Construction

The primary innovation is the integration of RetrievalAugmented Generation (RAG) techniques. The RAG implementation involves the integration of a large language model (fine-tuned on Song architecture and archaeology) with a vector-based retrieval system derived from a comprehensive knowledge base. This hybrid model overcomes the common limitations of LLM models, such as hallucinations and reliance on outdated data, by grounding each query in a curated set of sources. For instance, when inferring the configuration of the column grid or the roof type, the system retrieves analogous Song-dynasty temple plans and construction rules, thereby ensuring the historical validity of the generated content. The pipeline comprises two synergistic branches:

4.1.1 Textual Inference (NLP Model)

We apply natural language processing to the corpus of technical literature. Key parameters—component names, dimensional ratios, decorative motifs—are extracted via machine learning. The language model, fine-tuned on this specialized corpus, can then generate detailed, academic-style descriptions of the temple’s layout, structural system, and decorative style given the site data. This automates the generation of restoration hypotheses (e.g. identifying a Xieshan roof form or bracket-set configuration) in standard scholarly terms.

4.1.2 Image/3D Generation (Vision Model)

In parallel, a deep generative model (e.g. a diffusion model or GAN) is trained on imagery of Song-dynasty halls, archaeological illustrations, and existing reconstructions. Given an input of the inferred 3D framework, it produces high-fidelity visualizations (plan views, elevations, renderings) consistent with period aesthetics. The model learns to “complete” partially missing forms: for instance, generating plausible detail on a damaged column capital or predicting the missing cornice profile.

These two models work in concert under the RAG framework (Figure 6). The AI system first “reads" the partial site plan and point-cloud geometry, uses the knowledge base to infer the complete column grid and roof form based on Song conventions, and then generates both (a) a textual restoration report and (b) corresponding 3D/visual renderings. This AIGCdriven generative process effectively emulates the logical workflow of an architectural historian. Importantly, every generated outcome is traceable back through the RAG pipeline to specific sources and constraints, rather than being a blackbox hallucination.

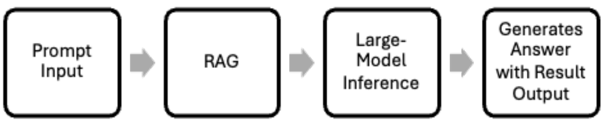

Figure 6. RAG-Based Flow

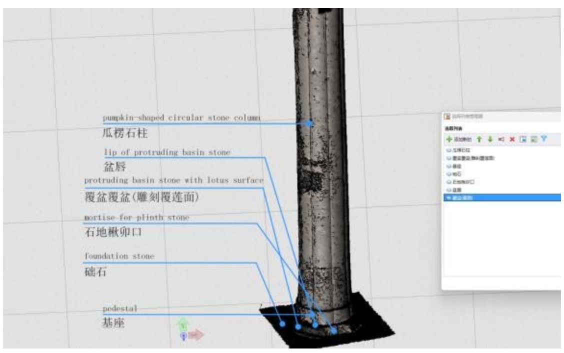

Figure 7. Digital Capture via Bentley iTwin-platform

4.2 AIGC Content Training and Generative Model

Concurrently, constraint-based parametric modeling is employed to ensure structural validity. The dimensions and typologies inferred from the AI are encoded as parametric rules, as illustrated by the local "construction chi" of 294 mm and bracket set standards from the Yingzao Fashi. Utilizing these constraints, a fully parametric three-dimensional model is constructed in a Building Information Modeling (BIM) environment (Bentley iTwin), which automatically enforces consistency (e.g., bay sizes, post dimensions, roof geometry). This approach stands in contrast to freehand modeling, which involves the integration of centuries-old empirical rules within the digital model. In this manner, any adjustment made to the model automatically triggers simultaneous updates to related elements. At each stage of the model's development, it is meticulously verified against both archaeological evidence and similar Song temples. Automated three-dimensional comparisons have the capacity to expeditiously identify any deviations from established patterns. This method is significantly more efficient than manually examining architectural texts. It has been determined that all final detailed components (beams, bracket sets, tiles) are to be stored in a Building Information Modeling (BIM) database. This process ensures the preservation of the full semantic and geometric reconstruction in a standard format. Also, The AI-driven pipeline proceeds through the following major steps:

4.2.1 Digital Capture & Archiving

High-resolution laser scanning and photogrammetry document the ruin’s current state at millimeter precision, creating the baseline geometry (Figure 7).

4.2.2 Knowledge Base Construction

Integration of multisource data (point clouds, site plans, literature, historical imagery) into an HBIM-compatible ontology (Figure 8). This database encodes Song-dynasty architectural theory and Gonghoulong-specific details as reusable knowledge.

4.2.3 RAG-Enhanced Model Training

Fine-tuning of LLMs on the domain corpus and constructing the retrieval index. The AI then infers missing structure (column grid, roof type, etc.) using RAG, simultaneously generating narrative descriptions and visual hypotheses.

4.2.4 Constraint-Driven 3D Modeling

Parametric reconstruction in a BIM platform, where Songdynasty construction rules and material constraints govern the assembly. Each generated element is automatically checked for
structural and stylistic consistency

4.2.5 Validation & Iteration

The digital model is compared three-dimensionally with reference data (other temple models, historical records). Discrepancies are reviewed by experts, and feedback is used to refine the knowledge base and AI parameters.

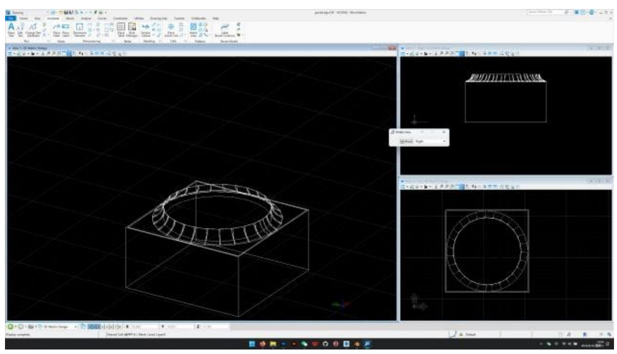

Figure 8. Point cloud cleaning and 3D reconstruction via Bentley iTwin-platform

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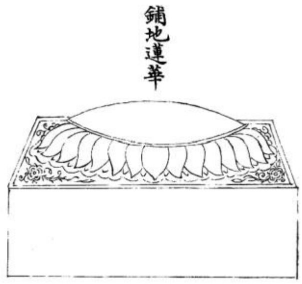

Figure 9. The pattern of lotus flower via “YINGZHAO FASHI”

4.3 Comparison with Traditional Restoration

The integration of comprehensive, BIM-compatible knowledge bases with RAG-enhanced AI generation and parametric constraints has been demonstrated to yield enhanced accuracy, consistency, and efficiency. The entire process, from data acquisition through modeling to validation, is designed for reproducibility and scalability, representing a significant advancement over prior practices. This approach is distinctly different from and improves upon conventional restoration methods:

4.3.1 Precision: Conventional reconstruction methods frequently depend on manual site drawings and photographic inference, both of which are susceptible to human error. The pipeline utilizes objective digital surveying techniques, enabling the acquisition of millimeter-level accuracy in the documentation of existing ruins. The employment of meticulous construction chi units and parametric constraints guarantees that the reconstructed form precisely corresponds to historical dimensional systems.

4.3.2 Scalability: Conventional methods are characterized by their labor-intensiveness and customization, necessitating distinct expert analyses for each site. In contrast, the AI-based workflow demonstrates scalability. Once the model has been trained on Song-dynasty data, it can be applied to other Buddhist Hall ruins with minimal retraining. The horizontal applicability of the framework, which is standardised to facilitate integration and streamline processes, is unattainable through manual restoration methods. Manual restoration is inherently limited in its capacity to incorporate new sites or data sources.

4.3.3 Reproducibility: The restoration decisions made by teams can vary. The data-driven pipeline under consideration is characterized by its comprehensive codification, which ensures the reproducibility of results when given identical inputs. Each stage of the process, including data capture, RAG inference, and parametric modeling, is governed by a set of algorithmic rules. Furthermore, the implementation of 3D digital models for validation purposes enables a rigorous comparison and verification of results by independent teams, thereby ensuring reproducibility. This approach stands in contrast to conventional expert-driven outcomes, which often lack formal documentation.

4.3.4 Embedded Expertise: Conventional digital restoration methodologies entail the superimposition of a generic model onto the ruins, whereas our approach involves the direct integration of domain expertise. The integration of RAG ensures that the AI is cognizant of Song's architectural practice, and constraint-based modeling enforces it. Conventional digital modeling techniques seldom incorporate such intricate semantic constraints. Consequently, the outcomes of our approach are both visually plausible and historically authentic.

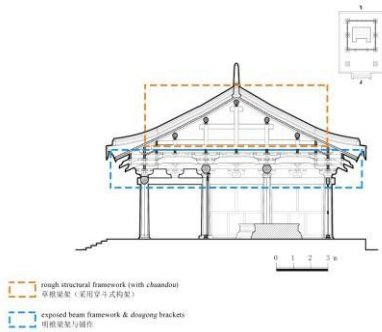

Figure 10. Transverse section of the main hall reconstruction. Drawing by Yu Ding

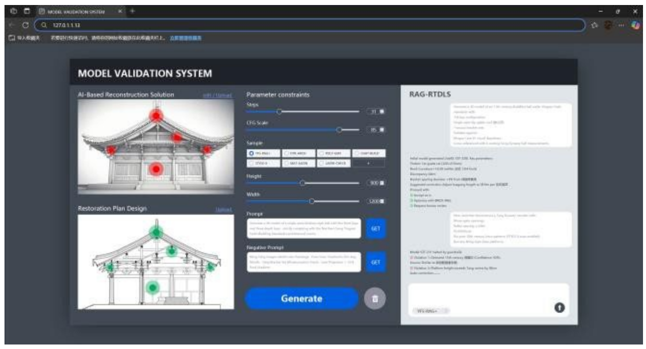

Figure 11. UI Prototype of the Model Validation System

4.4 3D Modelling Immersive Presentation Content Output

For the restored 3D modelling effects, we have accumulated sufficient digital materials to provide immersive 3D presentations of the historic buildings. This not only showcases the architectural heritage but also serves as an effective method for the digital preservation of the monuments. Below is a brief description of the technical solution (Figure 12).

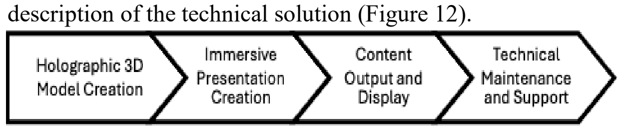

Figure 12. 3D Content Output Tech Solutions

After AI generates multiple sets of relatively accurate 3D models, detailed modeling of the architectural components (such as columns, beams, roofs, etc.) is carried out based on historical documents and the current state of the site. These models are stored as an HBIM digital foundation to accurately restore the building's form and structure (Figure 13).

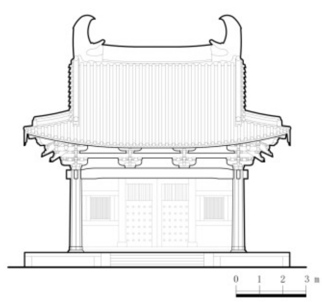

Figure 13. Facade of the main hall reconstruction Drawing by Yu Ding

Import the 3D modelling results into a virtual reality platform to create an immersive experience. Users can explore the restored ancient architectural site through VR devices, experiencing the historical atmosphere and cultural connotations of the architectural space. At the same time, AR technology is used to combine the digital model with the existing site, overlaying virtual content to enhance interaction within the real environment. Visitors or researchers can use AR devices to view the digital restoration status of the building on-site, enhancing their understanding and perception of the site. A user-friendly interface is designed to allow free exploration of the virtual environment, viewing architectural details from different perspectives, and even customized tours. Users can interact with the model through gestures, voice, or other interaction methods.

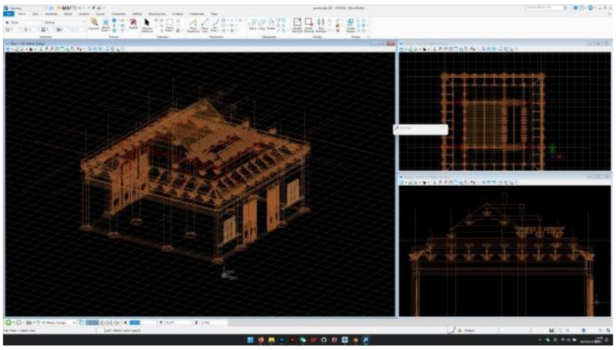
Figure 14. 3D modelling via Bentley iTwin-platform

Immersive presentation content should support output across multiple platforms, including VR devices, AR devices, PCs, and mobile devices, to ensure that different user groups can access and experience it flexibly. Existing technologies can integrate high-quality rendering techniques (such as ray tracing, texture mapping, etc.) to realistically present architectural details and simulate the effects under different lighting conditions, enhancing the visual experience. In addition to static displays, 3D animation videos can also be generated to showcase the entire process of architectural restoration or specific details, facilitating academic research or cultural dissemination.

5. Conclusion

In the future, we plan to expand in the following areas: First, we aim to broaden the knowledge base by incorporating more data from Song Dynasty and other historical sites to enhance the model's adaptability to different types of heritage. Second, we will optimize the details of the multi-modal generation model, improving rendering technology and physical simulations to enhance the realism of virtual restoration. Third, we will strengthen collaboration with archaeologists, refining restoration results through human-AI collaboration, creating a new paradigm of "**AI-assisted + expert review**" to balance efficiency and accuracy. We believe that vertical knowledge models will play an increasingly important role in cultural heritage preservation, digital museum development, and public education, injecting sustained momentum into the revival and inheritance of traditional culture.

At the same time, we recognize the demonstrative role of this research in similar architectural heritage across East Asia. The timber Buddhist temples in Zhejiang and Fujian are not only representative of China's ancient architectural heritage but also carriers of East Asian Buddhist architectural culture. Especially during the Song and Yuan dynasties, Buddhist architectural styles underwent significant transformations, profoundly influencing architectural aesthetics and religious symbolism. Through the application of AI restoration technology, we can uncover the historical evolution of these buildings and showcase their cultural and architectural wisdom to other regions in East Asia via digital platforms, driving the global dissemination of cultural heritage and fostering cross-cultural understanding, ultimately promoting the inheritance and re-recognition of East Asian Buddhist architecture.

Through our "digital archiving - intelligent deduction - dynamic intervention" framework, we propose a standardized model that is widely applicable to the protection of similar architectural heritage across East Asia. This framework significantly improves the efficiency and accuracy of heritage preservation, simplifies the restoration process, and ensures historical authenticity. The application of AIGC technology in architectural restoration can be extended from Gonghoulong Temple to other sites facing degradation or lack of documentation, providing a more precise and efficient protection strategy for East Asian timber architecture. We believe this research provides a model for the future development of digital restoration in East Asia, demonstrating how to combine architectural history with artificial intelligence, and opening new paths for preserving these valuable historical buildings for future generations.

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