A Case Study on the Digital Representation of Ancient Architectural Heritage - Focusing on the Digital Representation Process of Mireuksaji in Iksan, Korea

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Abstract

In Korea, although no ancient architectural structures have been preserved in their complete original form, the need for architectural representation has been continuously raised from a cultural tourism perspective, leading to the development of digital representation projects. This study focuses on the Mireuksaji Temple Site in Iksan, Korea, and aims to propose a digital representation methodology suitable for the Korean context by analyzing in detail the digital representation process of ancient architectural heritage sites. The process proceeds in stages: historical research and schematic design, augmented reality (AR) representation, online virtual reality (VR) representation, and ongoing maintenance. As digital representation serves as an alternative to the actual structure, high-quality output and precise spatial alignment are essential. Representation plans are subject to continuous revision based on new research findings. Since the digital representation of buildings is carried out in phases, highly interoperable file formats are required for effective integration and management.

1. Introduction

1.1 The Situation in Korea

In the field of Korean architectural history, the early Goryeo period is generally regarded as part of ancient history. Most traditional Korean buildings were constructed of wood and have been completely destroyed over time due to factors such as fire and war. As a result, there are very few surviving examples of intact ancient architecture.

Currently, only partial remains such as stone foundations or column bases exist as archaeological relics, and tangible evidence of ancient architecture is extremely limited. For this reason, physical restoration of ancient structures is realistically difficult, yet the necessity of restoration has been continuously raised in relation to heritage site utilization and the revitalization of cultural tourism. In particular, from the perspective of local tourism and economic development, there have been growing demands for on-site reconstructions that visitors can experience in person.

However, according to UNESCO World Heritage authenticity standards, physical restoration may actually compromise the authenticity of cultural heritage. As a result, physical reconstruction is discouraged from the standpoint of international guidelines and is difficult to implement in practice. In response to these circumstances, digital representation has increasingly attracted attention as a viable alternative. Digital representation utilizes augmented reality (AR) and virtual reality (VR) technologies to visually reconstruct lost architectural structures and provide visitors with immersive experiences. In particular, augmented reality overlays three-dimensional virtual images onto real-world environments, enabling the perception of non-existent objects as if they were present in physical space. Since initiating the AR-based digital representation project for the Central Gate of the Hwangnyongsa Temple Site in Gyeongju in 2017, the National Research Institute of Cultural Heritage of Korea has progressively expanded and applied various digital representation technologies for the utilization of ancient heritage sites as of June 2025.

1.2 Research Purpose and Methodology

This study examines the potential for utilizing ancient architectural heritage sites in Korea, where physical restoration is often unfeasible, by analyzing the case of the digital representation project conducted at the Mireuksaji Temple Site in Iksan. The use of digital technologies for representation has gained attention as an alternative approach for conveying the historical context and spatial structure of heritage sites, and this study explores the new possibilities such technologies offer for heritage utilization.

In particular, this study focuses on the use of digital technologies not merely as tools for visual reproduction, but as instruments that enable immersive, visitor-centered experiences. It analyzes the experiential content strategies, the process of adapting schematic designs, and the visualization methods applied in the digital representation of Mireuksaji Temple Site. Through this, the study aims to demonstrate that digital representation can move beyond simple information delivery to generate educational and cultural value. Ultimately, it seeks to propose a methodological direction for digital representation that aligns with the specific characteristics and practical constraints of Korea's ancient architectural heritage.

The structure of this paper is as follows: Chapter 2 outlines the overall process of ancient architectural representation; Chapter 3 examines key applications of digital representation at the Mireuksaji Temple Site, focusing on on-site augmented reality content and online virtual tours, along with an analysis of visitor survey results. Chapter 4 describes the phase-by-phase transformation of 3D modeling as the schematic design is implemented into digital content, and Chapter 5 presents conclusions and implications for the future use of digital representation in ancient architectural heritage.

2. Digital Restoration Process of Ancient Architecture at the Iksan Mireuksa Temple Site

2.1 Historical Research and Verification

Historical research is the most critical step in ensuring the authenticity of ancient architecture. It involves the comprehensive collection and analysis of data to derive a foundational representation plan. This process includes examining historical texts, paintings, excavation reports, and prior studies across a broad spectrum of sources. Additionally, comparable cases are referenced to propose reconstruction plans regarding structural principles such as layout, elevation, section, and overall composition.

Because it is realistically impossible to establish a 100% definitive representation plan, any new archaeological discoveries or emerging evidence may necessitate revisions to the proposed scheme. Historical research is therefore not a one-time task, but a continuously evolving process. Its depth and precision directly affect the historical credibility and visual completeness of the final representation output.

2.2 Schematic Design and 3D Modeling

Based on historical research, schematic drawings are developed by establishing standards for the plan, elevation, and structural systems. These drawings serve as a foundational guideline for the overall digital representation process and directly influence the accuracy and completeness of subsequent modeling stages.
Due to the nature of ancient architecture, information retrievable from physical remains is often limited. Therefore, representation plans must be progressively refined through iterative revisions between historical analysis and schematic design. Since two-dimensional drawings alone are insufficient for comprehensive spatial evaluation, they are converted into 3D models to allow for in-depth review of joint structures and inter-floor connections.

Among these, BIM (Building Information Modeling) is a component-based 3D modeling method that not only includes geometric data but also incorporates metadata such as material properties and related historical references. This data-driven approach enhances the reliability of the final representation and serves as persuasive evidence supporting the historical validity of the reconstructed model.

2.3 Augmented Reality Representation

In cases where physical reconstruction is not feasible due to the absence of remaining architectural structures, augmented reality (AR) technology offers a viable alternative for digital representation. AR overlays three-dimensional virtual images onto real-world spaces, making it an effective means of visually situating lost structures with spatial accuracy.

At the Mireuksaji Temple Site, AR content representing the central gate was developed using tablet PCs and smart glasses. This immersive experience allowed visitors to perceive the scale and form of the structure on-site without the need for actual reconstruction, providing a compelling alternative to physical restoration.

2.4 Virtual Reality Representation

Following the implementation of the AR content, user feedback indicated a growing demand for non-face-to-face content that offers broader informational access beyond the limitations of on-site experiences. In response, an online-based virtual reality (VR) tour was conceptualized and produced. The entire Mireuksaji site was digitally captured through broadband 3D scanning and photogrammetry, enabling high-resolution representation. Within the separately developed web-based VR platform, users can navigate the heritage site step-by-step through a "Click & Go" interface based on 360° panoramic modeling. Key locations throughout the site are linked to multimedia information such as historical explanations, related research data, and videos documenting the representation process.

This VR content presents a digital representation model that enables the study and experience of ancient architectural heritage without temporal or spatial constraints and may serve as a valuable prototype for application to other types of heritage assets in the future.

2.5 Maintenance and Updates

As of December 2024, digital representation efforts have been limited to the central gate of the Mireuksaji Temple Site. However, additional structures are planned to be digitally represented through both AR and online platforms in the future. As this project is not a one-time undertaking but a continuously evolving process, a long-term maintenance strategy that reflects technological advancements is essential.

Over time, previously developed content may become outdated. Therefore, it is necessary to implement a management strategy that ensures consistency and integration between new and existing data. This includes utilizing widely supported software conducive to long-term maintenance, establishing high-quality foundational data, and designing content with scalability in mind.

3. Development of Site-Based Augmented Reality and Online Virtual Reality Content

3.1 Development of Site-Based Augmented Reality(1)

Mireuksaji Temple in Iksan was established in the 7th century during the reign of King Mu of Baekje, with the intention of ensuring royal peace and promoting the enlightenment of all beings. The temple features a unique spatial layout known as the "three pagodas and three main halls," in which three temple compounds are aligned from east to west.

In this project, the central gates (jungmun, 중문) of each of the three compounds were digitally represented using augmented reality (AR). The east and west central gates share the same configuration—single-story buildings with gabled roofs. The central compound gate (jungwon jungmun, 중원 중문) was reconstructed in two forms: one with a two-story structure featuring a pyeonggongpo (평공포) bracket system and a hip-

(1) The content of section 3.1 of this paper is a revised and supplemented version of Choi and Jung (2024).

and-gable roof (ujingak, 우진각), and the other with a haang (하앙) structure and a transitioned hipped-gable roof (kkeokim paljak, 꺾임팔작).

The gate structures were represented at full scale to enhance the viewer's sense of realism when experienced on-site. In addition to the gates, the AR content includes seven modules in total, providing visualized information on the temple's historical background, excavation process, and the architectural construction of the stone pagoda.

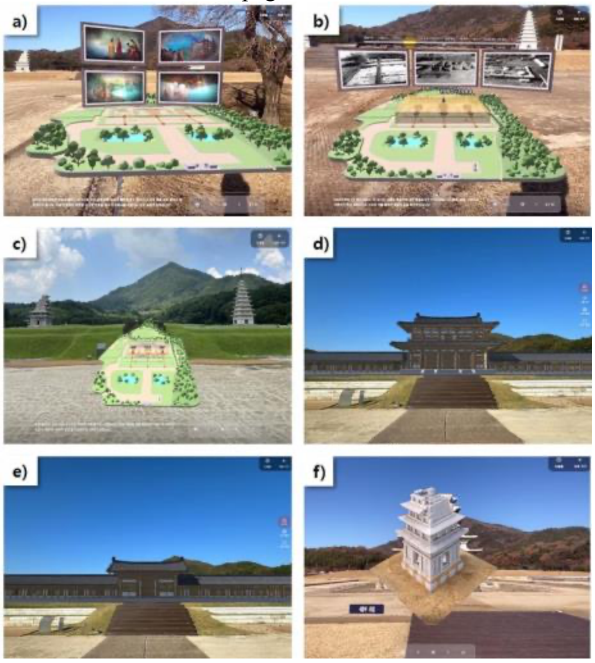

Figure 1. AR execution image of seven docent guides (a) History of Mireuksa Temple Site; (b) Study Process of Mireuksa Temple Site; (c) Meaning of Central Gate, Mireuksa Temple; (d) Central Central Gate; (e) East and West Central Gate; (f) Demolition and Assembly of Mireuksa Temple Site Stone Pagoda (NRICH, 2023).

The AR content is designed to be experienced within a large open space measuring approximately 150 meters in width and 300 meters in length. Therefore, it was important to enable users to easily recognize both their own location and the content targets distributed throughout the expansive site. To achieve this, a mini-map was created using the terrain and layout of the Mireuksaji Temple Site, and a navigation system was applied to display the positions of both the user and the available AR content.

Key interactive features include the following: First, when users select a major architectural component, the selected part is visually highlighted through color changes, and detailed information is provided to help users intuitively understand each structural element. Second, the Central Gate of the central compound (jungwon, 중원) was reconstructed in two different forms, allowing users to compare the alternatives. Users can freely zoom in, zoom out, and rotate the 3D model 360 degrees. Third, a construction animation simulates the step-by-step building process. Each phase of construction is grouped, allowing users to isolate and explore specific units separately. Fourth, users can take photos of themselves standing in front of the reconstructed AR model of the Central Gate and send the image via email. Finally, a seasonal VR background effect was developed to enhance engagement, representing the four seasons through particle effects.

Unlike VR, which is fully virtual, AR is based on real-world environments and offers high levels of immersion by enabling real-time interaction with physical space. To implement the AR model of the Central Gate at the Mireuksaji Temple Site, a digital model was first created. The production process followed a sequential workflow: 3D modeling, UV editing, texture creation, and shading.

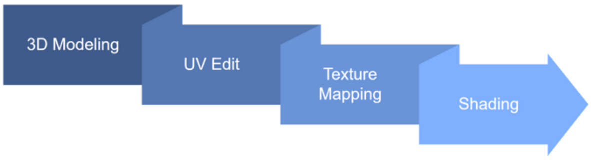

Figure 2. Modeling production process.

The 3D modeling data was created using polygonal structures in three-dimensional space, utilizing 3ds Max and Maya—programs known for their broad applicability and ease of modification. In the case of the Mireuksaji Central Gate, where physical data cannot be collected on-site due to the absence of the original structure, modeling was conducted by integrating data from the remaining structural components and findings from historical research.

UV editing refers to the process of mapping images onto the surface of 3D models by converting them into 2D layouts, which resemble development drawings. Rather than replicating the size and form of the original modeling precisely, UV size and layout were adjusted to emphasize key visual features.

Texture production involved drawing 2D images based on UV data. Textures were created with consideration for the characteristics of PBR (Physically Based Rendering), and to optimize graphic resources, only essential texture types were extracted and applied, even though using more textures could enhance quality.

Shading was performed within the Unity environment by applying the textures to designated PBR shader slots provided by the engine, completing the visualization process.

The most critical aspect of the Mireuksaji AR representation of the Central Gate was achieving accurate spatial alignment of the 3D data in the field. While extracting feature points from objects is ideal for AR implementation, the site of Mireuksaji is a wide, empty space. Although object rendering based on GPS is possible, increasing accuracy would require the addition of external GPS sensors. However, such sensors increase the weight of the devices, making them unsuitable for long-term outdoor use. Therefore, to minimize positioning errors, the system estimated the user's location using the built-in GPS of a tablet PC and enhanced accuracy by combining SLAM (Simultaneous Localization and Mapping) with marker-based tracking.

To experience AR content on-site, devices must be used. Outdoor environments introduce visibility challenges due to sunlight and portability issues. To address this, a head-mounted display (HMD) in the form of smart glasses was adopted, enhancing user convenience and immersion by allowing direct viewing of the augmented Central Gate. The selected device, Magic Leap 2, was chosen for its outdoor visibility, high compatibility, and sustainability. Unlike other devices that use physical visors, it features a dimming function that darkens the user's view, enabling clear visibility of AR content in daylight and allowing users to adjust the brightness freely for safety. The lightweight glasses (260g) reduce fatigue even after prolonged use and offer a wide field of view (FOV) of 70° and a refresh rate of 120Hz, maximizing immersion.

The tablet PC used for AR was selected for its high performance and lightweight build. Its small size required UI/UX adjustments to ensure text and image readability, and a bright-colored model was selected for visibility under strong sunlight.

To assess the usability and identify areas for improvement, a user trial of the Mireuksaji Central Gate AR content was conducted from November 17 to 18, 2023, involving 52 participants. According to the survey, approximately 90% expressed interest in experiencing the AR content again, and 87% said they would recommend it to others. As for the most satisfying content (multiple selections allowed), 88% cited the reconstructed AR architecture of Mireuksaji, followed by 26% for cultural heritage information, 25% for the photo capture and email service, 11% for the construction animation, and 9% for interactive manipulation of the architecture.

Regarding dissatisfaction, 13% pointed to the cultural heritage explanations, followed by 11% for architectural manipulation, 7% each for the AR building and construction animation, and 5% for the photo service. The most favored feature was the reconstruction of the lost structure, which users appreciated for its visual clarity in an otherwise empty site. On the other hand, dissatisfaction with the explanatory content was due to different reasons depending on the audience: experts requested more complete research-based content, while general users found the terminology difficult to understand. This indicates the need for content tailored to both expert and general audiences. Additional feedback included the need for more diverse content types, technical improvements, and enhanced device performance. For tablets, users requested better screen resolution and lighter weight, while for smart glasses, they asked for improved outdoor visibility and reduced dizziness.

3.2 Development of Online-Based Virtual Reality Content

To launch a nationwide public service by 2025, a virtual environment was developed for experiencing the central middle gate of Mireuksa Temple. The VR tour offers an immersive way to understand the structure’s historical value without time or location constraints. It uses a 360° VR format that brings the Mireuksa site into everyday environments.

Aerial photography, wide-area 3D scanning, and photogrammetry were used to collect data for highly accurate terrain modeling. Using Reality Capture, point cloud data was converted to polygon data to create precise 3D models. These were exported in FBX format for real-time rendering with Unreal Engine and Twinmotion.

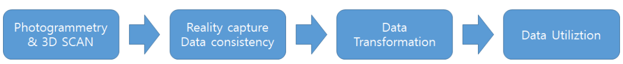

Figure 3. Mireuksa Temple Site Modeling production process

To enhance immersion, a GIS-based site model was also developed, combining broadband 3D scans and Google Web Geodata to reproduce realistic topography. The outer environment (terrain, roads, buildings, vegetation) was visualized using Megascan data. Simulations allowed the landscape and vegetation to change naturally based on time and season.

The content uses a "Click & Go" interface, allowing users to move through preset paths by clicking. It supports 360° exploration of interior and exterior areas via WebVR. While optimized for PC, the platform is responsive and accessible via smartphones, tablets, and laptops.

Figure 4. Information Point Locations in the Virtual Tour & Virtual Tour Interface of Mireuksa Temple (Image from the Aha! Virtual Cultural Heritage Experience platform).

The content was designed to include both educational materials related to Mireuksaji and features aimed at enhancing user engagement. The educational content covers: (1) historical background, excavation records, and restoration process information; (2) construction process understanding through simulation; and (3) comparative explanations of different restoration proposals, offering a comprehensive overview of the digital representation of Mireuksaji.

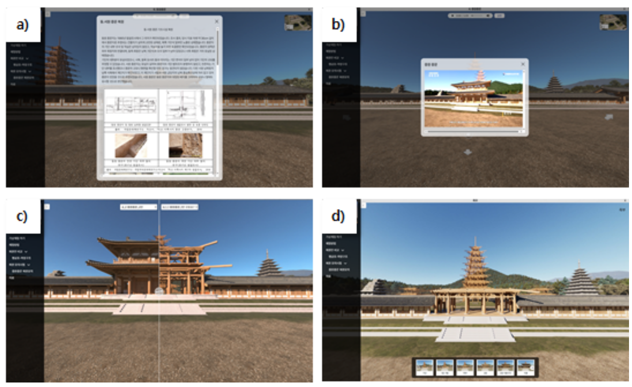

Figure 5. VR execution image of contents (a)Provide Web page information b)Provide video information c)Comparison of restoration plans d)Restoration Simulation Pagoda (Image from the Aha! Virtual Cultural Heritage Experience platform)

Information is provided interactively via UI/UX elements linked to specific data points. Users can access content such as videos and web pages that display excavation photographs, restoration progress at different stages, and supporting historical research materials. For more detailed information, web documents (texts and images) are provided, with links to related PDFs or excavation reports as needed.

The construction simulation visualizes the restoration process of the Central Gate through an animated sequence, allowing users to understand the architectural techniques and the historical significance of cultural heritage restoration. The comparative representation of restoration proposals—such as the Pyeonggongpo structure and ha-ang structure types of the Central Gate—was designed using intuitive graphics so that both academic audiences and general users can easily grasp the differences and underlying concepts of each scheme.

To enhance user engagement, various content formats such as short videos and infographics were introduced to reduce user fatigue. Intuitive graphics were used not only to convey academic information but also to make the content easily understandable for general audiences, thereby improving user focus. In addition, realistic high-resolution graphics and simulation/FX effects were applied to maximize immersion.

Figure 6. Intuitive graphics and Seasonal Change FX Effect (Image from the Aha! Virtual Cultural Heritage Experience platform).

The online virtual reality (VR) content was designed as a first-person activity-based tour, built on user-centered and intuitive UX/UI principles. Advanced technologies such as Unreal Engine, Twinmotion, Reality Capture, Google OSM (Web geodata), and Blender were utilized. Additionally, the content was optimized for web-based operation through the use of panoramic images and videos.

A user survey on the VR content of the Central Gate at the Mireuksaji Temple Site was conducted from April 28 to June 4, 2025. The survey was promoted through the National Research Institute of Cultural Heritage (NRICH) website, its social media channels, and Korea's national public communication platform. A total of 96 people participated. The results showed that 92% of respondents expressed a desire to re-experience the virtual tour, and 94% indicated they would recommend it to others. When asked about the most satisfying aspects of the content (multiple responses allowed), participants selected: experiencing the reconstructed Mireuksaji architecture (91%), 360° building exploration (55%), cultural heritage explanations (39%), comparison of representation options (25%), and reconstruction process simulations (21%). The most unsatisfactory aspects included: cultural heritage explanations (34%), comparison of representation options (28%), 360° building exploration (22%), reconstructed building experience (21%), and reconstruction process simulations (19%). Areas identified for improvement included increased public outreach (48%), greater diversity of content types (46%), enhanced content quality and improved usability (UI/UX) (26%). Additional feedback highlighted the need for free navigation beyond the current Click & Go format, multilingual support, and design improvements.

The most satisfying experience was the visual exploration of the reconstructed Mireuksaji architecture, which was valued for allowing users to view buildings that no longer exist. Meanwhile, the most unsatisfactory content was the explanatory section on cultural heritage, indicating a user demand for more historical and contextual information about the heritage and its reconstruction process. The strong emphasis on the need for better promotion underscored that creating VR content alone is not sufficient—public awareness and accessibility are equally important. The feedback also confirmed users' desire for varied experiences, improved content completeness, and refined design.

4. Modeling Changes by Development Stage

4.1 Modeling Based on the Basic Design

In the initial stage of the digital representation, the schematic design was carried out based on the results of prior historical research. Using Archicad and the Building Information Modeling (BIM) method, the structural characteristics and floor plans of each central gate (jungmun) were incorporated. The East and West Central Gates were designed as identical single-story structures with gabled roofs, while the Central Central Gate (Jungwon Jungmun) was represented as a two-story structure in two versions: one featuring a pyeong-gong-po bracket system with a hip roof, and the other utilizing a ha-ang structural system with a compound hip-and-gable roof.

The schematic design referenced in-ja (人자) beam structures—classified as an early traditional technique—and construction elements generally considered characteristic of Baekje architectural style.

The initial plan focused solely on reconstructing the central gate itself, but due to concerns that the building might appear visually disconnected from its surrounding context, portions of the surrounding corridor (hoerang, 회랑) were also implemented in simplified form. This decision was based on expert consultation, even before detailed historical research or formal design of the corridor had taken place, and aimed to preserve the visual continuity of the overall landscape.

While the design process was grounded in historical research, details such as floor plan layout, jointing methods, and roof types were adjusted through technical reviews at each stage. Since ancient architectural representation does not rely on a single interpretation and must adapt to ongoing archaeological discoveries and textual analyses, it inherently possesses a hypothetical nature.

Accordingly, this schematic design was established by selecting the most reasonable option among multiple representation plans and refining it with detailed structural and dimensional specifications—ensuring both clarity in design and feasibility for digital implementation. This approach was made possible by the inherent advantage of digital representation, which allows for the visualization of diverse interpretations. The finalized schematic design served as the foundational reference for subsequent 3D modeling and content production.

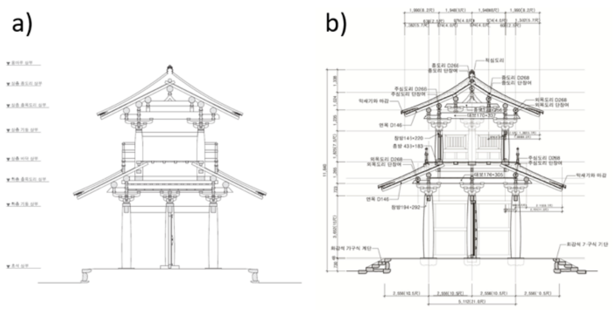

Figure 7. Comparison of the Middle Gate: a) Historical Representation Plan (NRICH, 2019) b) Basic Design Drawings for Content Implementation (NRICH, 2022).

4.2 Modeling for Augmented Reality

During the implementation of augmented reality (AR) content based on the schematic design, certain modeling elements were adjusted to enhance visual realism and immersion within the actual experience environment. Since digital representation is intended to serve as a substitute for physical architectural structures, both the accuracy of on-site technological integration and the visual completeness of the model had to be carefully considered.

First, the originally open space between the door beams and main columns—originally composed of wooden structural elements—was modified to a closed wall in the AR environment to improve spatial perception. Second, the spacing of the balustrades was reduced to achieve more realistic proportions. Third, the hoe (회) finish applied to the eaves' edge, which had been omitted during the design stage, was rendered in detail within the AR content (see Figures 8–10).

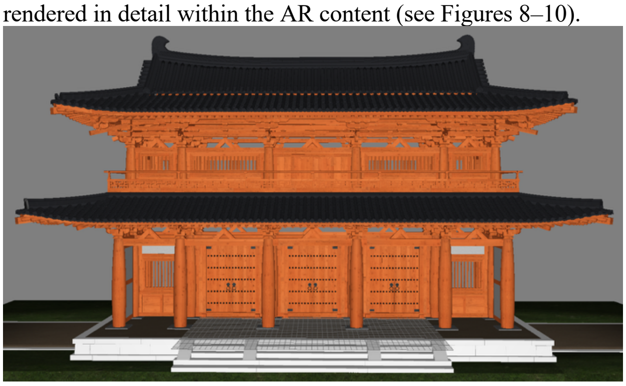

Figure 8. Initial AR Model: Wall not applied, wide balustrade spacing.

Figure 9. Revised AR Model: Wall applied, balustrade spacing adjusted.

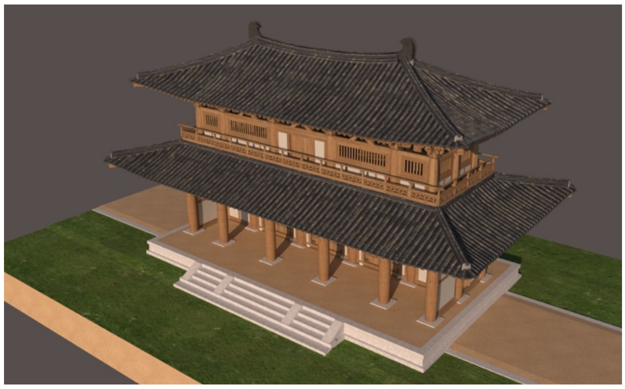

Figure 10. Revised AR Model Overview.

Additionally, although the colonnade had not yet been fully designed during content production, a minimal version was included to prevent the middle gate from appearing disconnected from the surrounding architectural context. This helped convey the spatial continuity of the architectural complex to users and enhanced their overall understanding of the site.

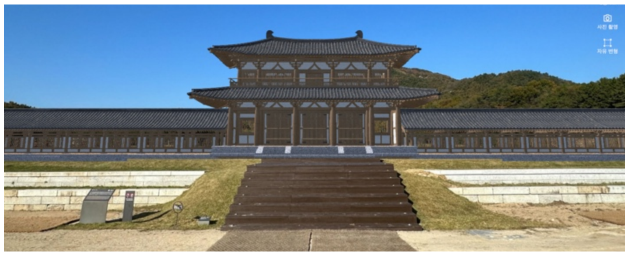

Figure 11. AR Restoration Model Reflecting the Link between the Middle Gate and Colonnade.

Unlike fixed-point viewing, augmented reality (AR) content is experienced by moving through the entire site and encountering structures in real time. Therefore, in addition to modeling accuracy, integration with various location-based technologies—such as GPS, SLAM (Simultaneous Localization and Mapping), and marker-based tracking—is essential. As a result, the restoration model was designed and refined beyond simple visualization, with a flexible structure that could respond to technical conditions. These adjustments were part of a design strategy aimed at enhancing the detail of the Middle Gate model and improving the viewer's sense of immersion.

4.3 Modeling for Virtual Reality

After the site-based AR content experience, many users expressed the need for expanded information and freer accessibility. In response, an online-based virtual reality (VR) content was additionally developed to enable the experience of ancient architecture regardless of location.

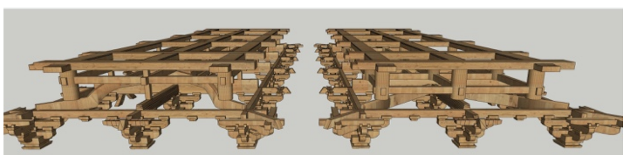

Figure 12. Comparison of Eaves-End Bracket Configurations: hongyebo(left), jikbo(right) (modeling by Jung, J. Y., 2024).

In this process, the restoration model was reconstructed in a more precise and refined form than the AR content, incorporating the results of state-level historical research to enhance the authenticity of the content. For example, the original model applied curved bargeboard (hongyeobo, 홍예보) to the corner rafter decoration (gwipo, 귓보), but this was revised to straight bargeboard (jikbo, 직보) based on a review of ancient architectural precedents.

This revision reflected the historical research findings that the use of curved bargeboards was uncommon in ancient Korean architecture. In the virtual reality (VR) content, the corridor structure—initially simplified in the AR stage—was visualized more clearly. Although the restoration of the corridor is still under research and has not yet been finalized, this addition served as a complementary measure to better communicate the spatial continuity of the overall architectural complex. Based on a provisional schematic design, the form of the corridor was partially represented to help viewers understand the middle gate in relation to its surrounding context.

Additionally, structural frameworks for other buildings slated for future restoration were temporarily modeled in 3D and rendered in a semi-transparent form. These structures have not yet undergone formal verification and were represented based on provisional design plans as visual references. This approach was intended to help users understand not only the buildings already restored but also the broader context of architectural elements planned for future restoration.

In this way, the restoration models were restructured in accordance with the goals of VR content development ensuring both historical accuracy in the details and providing an immersive, location-independent experience.

Figure 13. Panoramic View of Mireuksa Central Gate (Image from the Aha! Virtual Cultural Heritage Experience platform)

Figure 14. Representation of Buildings Planned for Restoration: The colonnades on both sides of the central gate are emphasized for realism, while other structural elements are modeled with translucency (Image from the Aha! Virtual Cultural Heritage Experience platform**)**

5. Conclusion

In the context of Korea, although no ancient architectural structures have been preserved in their complete original form, this study documents the process of digital representation conducted for the Mireuksaji Temple Site in Iksan. The project was carried out in several stages: historical research and schematic design (BIM modeling), augmented reality (AR) content development, and the creation of an online virtual reality(VR). As the digital representation is intended to serve as a substitute for the physical structure, AR content based on the actual site was prioritized. High visual fidelity and accurate spatial alignment were essential. To meet the growing demand for broader public access and information, the online virtual reality(VR) was developed subsequently.

Throughout the entire process, the digital models were continuously revised and refined in response to new research findings. Due to the lack of complete historical data, it was not feasible to reconstruct the entire building complex at once; instead, the process was carried out incrementally. Because the reconstruction progresses in stages, it is necessary to use file formats with high interoperability, allowing newly reconstructed buildings to be added and integrated with existing ones.

To fulfill the dual goals of advancing research and enhancing practical applicability, the models were continuously updated, refined. This paper is meaningful in that it transparently presents how digital representations of Korean ancient architecture evolve in response to both scholarly insights and real-world constraints.

Further theoretical investigation is needed to position this work within the broader international discourse on digital cultural heritage.

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