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Research on the Digital Conservation Technology Path for Historical Buildings from the Anti-Japanese War in Chongqing: Based on HBIM Framework and Multimodal Representation

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Abstract: The historical buildings from the Anti-Japanese War in Chongqing serve as significant material witnesses to the urban memory of the rear area during the war and represent spatial texts interwoven with mountain architectural forms and wartime social life. Addressing issues such as diverse types, complex sites, scattered data, and the disconnection between Conservation and dissemination, this paper introduces technologies such as HBIM (Historical Building Information Modeling), AI semantic segmentation, knowledge graphs, digital twins, 3D Gaussian Splatting (3DGS), and WebXR. It proposes a digital Conservation pathway of "multi-source collection—Scan-to-HBIM—semantic enhancement—digital twin—multimodal dissemination". Using digital models of historical buildings from the Anti-Japanese War in the Nanquan area as samples, the paper compares modeling and dissemination strategies across different Conservation levels, spatial scales, and utilization objectives, focusing on cases such as Tingquan Building, Kongyuan, Kong Lingjun's Villa, Kongyuan Administrative Building, Lin Sen Bathhouse, Wei Lu, the President's Residence, Bamboo Grove Villa, and the former site of the Research Department of the Central Political School. The study suggests that digital Conservation of historical buildings from the Anti-Japanese War in Chongqing should form a hierarchical system consisting of "archive layer—management layer—monitoring layer—dissemination layer". High-precision collection and HBIM ensure authenticity, knowledge graphs and digital twins support continuous updates, and 3DGS, panoramic tours, and WebXR enhance public accessibility, serving Conservation decision-making, academic research, course instruction, and social sharing.

Keywords: Historical buildings from the Anti-Japanese War in Chongqing; Digital conservation; HBIM; Digital twin; 3D gaussian splatting (3DGS)

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1. Introduction

During the Anti-Japanese War, Chongqing served as the political, military, and cultural center of the rear area, leaving behind a significant number and diverse range of historical buildings. These remnants are not isolated relics but spatial witnesses left by the interweaving of wartime national operations, social life, and the growth

patterns of mountain cities. They include official residences, offices, educational institutions, and former residences of celebrities, as well as air defense projects, mountain gardens, and ancillary facilities. With urban renewal and the expansion of tourism scenes, some buildings face issues such as structural aging, spatial distortion, and fragmented interpretation. Traditional methods relying on paper archives, two-dimensional drawings, and individual repairs can no longer meet the composite needs of "precise cognition—dynamic management—public dissemination" [1,2].

In recent years, digital heritage research has advanced rapidly, and HBIM (Historical Building Information Modeling) has evolved from a mere three-dimensional modeling tool to a digital foundation connecting surveys, documentation, restoration, exhibition, and public participation. Related studies indicate that HBIM is accelerating its integration with XR, artificial intelligence, knowledge graphs, and digital twins, and the digital Conservation of cultural heritage is moving from "model display" to "semantic governance" and "lifecycle management". This implies that the digital Conservation of historical buildings from the Anti-Japanese War in Chongqing should not stop at one-time modeling but should establish a complete system from collection and documentation to operation, maintenance, and dissemination [3].

Based on this, this paper focuses on the key technological aspects of digital Conservation for historical buildings from the Anti-Japanese War in Chongqing and proposes an overall pathway of "multi-source collection—Scan-to-HBIM—semantic enhancement—digital twin—multimodal dissemination". Using digital models of historical buildings from the Anti-Japanese War in the Nanquan area as the primary samples, it discusses three key issues: first, the particularities of such heritage in terms of object attributes and real-world situations; second, how Conservation, management, and dissemination can be reorganized within the same technological chain; and third, how to form differentiated implementation strategies based on building types, Conservation levels, and utilization objectives.

2. Object characteristics and practical bottlenecks in the digital conservation of historical buildings from the Anti-Japanese War in Chongqing

From the perspective of heritage attributes, the outstanding characteristics of historical buildings from the Anti-Japanese War in Chongqing are not merely their "antiquity" but their composite value structure. They serve as historical evidence of the wartime urban spatial order and carry memories of events such as conferences, education, diplomacy, residence, and air defense. They contain not only structural information about the buildings themselves but also the spatial experiences of the mountain city created by slopes, terraces, retaining walls, courtyards, and plant landscapes. Therefore, the objects of digital Conservation are not merely geometric facades but a synthesis of "building entity—site environment—historical events—usage memories".

From a technological perspective, the digital Conservation of historical buildings from the Anti-Japanese War in Chongqing faces at least four bottlenecks: first, fragmented existing data, with historical archives, survey information, photographs, repair records, and exhibition materials scattered across different departments and private collections; second, the coexistence of mountainous scenes and complex spaces creates blind spots for single collection technologies, with drones struggling to penetrate indoors and into caves, and ground laser scanning limited in efficiency on roofs, under tree canopies, and in narrow spaces; third, many digital outcomes remain at the stage of "static three-dimensional browsing", lacking component semantics, disease records, and management interfaces; and fourth, a stable conversion chain has not yet been formed between digital outcomes and exhibition dissemination.

Domestic and international studies indicate that multi-source collection, parametric component families, non-geometric information loading, and multi-platform visualization are effective pathways to overcome these

bottlenecks. Especially in the study of wooden and complex historical buildings, HBIM can unify point clouds, photographs, materials, structures, diseases, and repair records into the same model through component-level modeling and information mapping. If further connected to monitoring data and interactive interfaces, digital models can be upgraded from static archives to dynamic management tools [4].

3. Construction of a technological pathway for the digital conservation of historical buildings from the Anti-Japanese War in Chongqing

3.1. Overall framework and technological stratification

The digital Conservation of historical buildings from the Anti-Japanese War in Chongqing is not merely the superposition of single modeling or display technologies but a composite process that integrates surveys, collection, semantic modeling, dynamic governance, and dissemination and utilization. To avoid fragmentation of technological links, it is necessary to clarify the functional divisions and hierarchical relationships of each technological module within the overall framework. See **Table 1**.

Table 1. Recommended technology stack for the digital conservation of historical buildings from the Anti-Japanese War in Chongqing

Phase	Recommended technology	Main function	Applicability
Basic survey	GIS database creation, archival review, field mapping	Identify objects, types, ages, and distribution	Form a survey list and basic archival records
Data acquisition	TLS, UAV oblique photogrammetry, handheld SLAM, close-range photogrammetry	Capture external morphology, internal space, and detailed textures	Suitable for mountainous terrain, multi-courtyard complexes, and intricate spaces
Semantic modeling	Scan-to-HBIM, component family library, IFC mapping	Carry geometric and non-geometric information	Supports conservation management and subsequent updates
Intelligent identification	Semantic segmentation, image recognition, assisted annotation	Improve efficiency of modeling and damage identification	Suitable for census phases and review of key samples
Dynamic monitoring	Temperature/humidity sensors, crack monitors, illuminance sensors, pedestrian flow sensors	Long-term preservation and maintenance alerts	Suitable for establishing digital twin pilots with key samples
Public dissemination	3DGS, WebXR, VR/AR, panoramic roaming	Lightweight publishing and immersive experiences	Suitable for museums, classrooms, and online platforms

Based on the summarization of the technological stack, **Figure 1** illustrates the overall roadmap from current situation investigation to semantic modeling, digital governance, and ultimately to multimodal dissemination, emphasizing the hierarchical relationship of "authoritative bottom-layer data—structured middle-layer semantics—lightweight upper-layer dissemination".

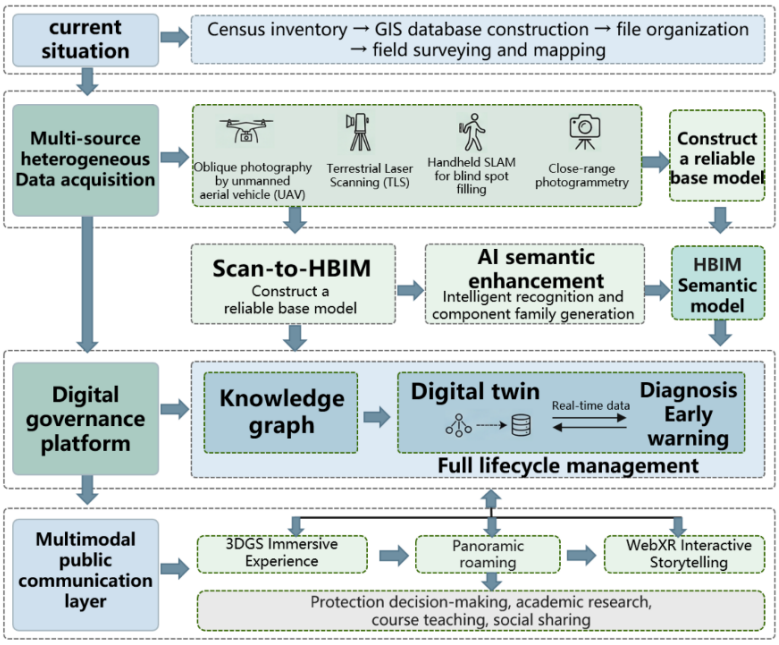

Figure 1. Overall technical roadmap for the digital preservation of historical buildings from the Anti-Japanese War period in Chongqing.

3.2. Key technical links and implementation points

After clarifying the overall technical framework, the digital preservation of historical buildings from the Anti-Japanese War period in Chongqing can be refined into five key links: collection, modeling, identification, monitoring, and dissemination, which jointly support preservation, research, and utilization.

3.2.1. Multi-source heterogeneous data collection: Constructing a reliable base model

Most historical buildings from the Anti-Japanese War period in Chongqing are located in mountainous environments, sloping courtyards, and dense vegetation scenarios. A combined approach of "drone oblique photography + terrestrial laser scanning + handheld SLAM for blind spot filling + close-range photogrammetry for fine texture collection" is recommended. Drones are responsible for capturing building group relationships, roof shapes, and site environments; terrestrial laser scanning is used for facades, interiors, staircases, and detailed geometry; handheld SLAM is employed in narrow passages, air-raid shelters, and stairwells where it is difficult to set up stations; and close-range photogrammetry is utilized for collecting details of doors, windows, bricks, stones, wooden structures, and damage. For key buildings, infrared thermal imaging and humidity inspection methods can also be added to form a comprehensive base map of "shape-material-damage".

3.2.2. Scan-to-HBIM: From point clouds to semantic models

The key to HBIM does not lie in converting point clouds into three-dimensional shells but in establishing a retrievable, traceable, and updatable information system based on components and spaces as units. This paper suggests dividing modeling objects into six levels: individual buildings, spaces, components, materials, damage, and events, and recording their names, coordinates, functional changes, component types, material properties, damage information, and repair and exhibition events, respectively, so that the model can support both academic research and subsequent maintenance and exhibition services [5].

3.2.3. AI semantic enhancement: Improving the efficiency of batch modeling and damage identification

For census-type projects, there are a large number of historical buildings from the Anti-Japanese War period in Chongqing with complex types, and relying solely on manual processing of point clouds and images incurs high costs. In recent years, HBIM research has incorporated deep learning and point cloud semantic segmentation into the modeling process, which can be used for pre-identification of walls, columns, doors, windows, roofs, and decorative components, as well as assisting in damage classification and label generation [6]. However, since Anti-Japanese War buildings often bear traces of later additions, demolitions, and replacements, the algorithm results must still be reviewed by architectural historians, conservationists, and designers; AI is more suitable for undertaking tasks such as "pre-segmentation, pre-labeling, and anomaly screening" rather than replacing professional judgment.

3.2.4. Digital twin and knowledge graph: Constructing a dynamic updating mechanism

The long-term value of digital preservation does not lie in one-time modeling but in forming future-oriented dynamic recording and governance capabilities. If sensors, alarm rules, maintenance logs, and semantic relationships are written into a unified system, and a knowledge graph is used to connect materials, damage, repair events, component relationships, and environmental thresholds, conditions can be provided for early warning, inquiry, and maintenance decision-making. This is particularly crucial for Anti-Japanese War buildings in Chongqing's hot, humid, rainy, and sloping environment [7,8].

3.2.5. 3DGS and WebXR: Constructing a lightweight public dissemination layer

Traditional point cloud and HBIM models have high accuracy but large file sizes and slow loading times, which are not conducive to public access. 3DGS has been rapidly applied to cultural heritage and architectural scenarios in recent years and is becoming an important supplementary technology for public dissemination. For historical buildings from the Anti-Japanese War period in Chongqing, a more reasonable approach is not to replace authoritative archive models with 3DGS but to form a "dual-layer expression": the underlying layer preserves authoritative archives with point clouds and HBIM, while the upper layer achieves browsing, guiding, and learning tasks with 3DGS, panoramic roaming, and WebXR, thus forming a composite form of "data preservation + online access + interactive storytelling" [9–11].

4. Case Study: Typological analysis of digital models of Anti-Japanese War historical buildings in the Nanquan area

To test the applicability of the aforementioned technical paths in specific scenarios, this paper selects digital models of Anti-Japanese War historical buildings in the Nanquan area as case samples, covering various types such as national key cultural relic Conservation units, municipal and district-level cultural relic Conservation units, ancillary buildings, former residences of celebrities, and large courtyard sites. The samples exhibit significant differences in spatial scale, functional attributes, and conservation goals, reflecting the typological characteristics of digital preservation of historical buildings from the Anti-Japanese War period in Chongqing. See **Table 2**.

Table 2. Digital model samples of Anti-Japanese war historical buildings in the Nanquan area and their research directions

No.	Building name	Conservation attribute	Digital focus	Research direction
1	Tingquan Building (Lin Sen's Villa)	Major Historical and Cultural Site Protected at the National Level	Digital surveying and mapping—value identification—renewal design—presentation and dissemination	To validate the collaborative approach between conservation renewal and narrative presentation of historical architecture
2	Kongyuan (Kong Xiangxi's Mansion)	Major Historical and Cultural Site Protected at the National Level	Multi-source surveying and modeling—spatial integration—adaptive reuse	To verify the feasibility of panoramic display, digital exhibition hall prototypes, and integration into curriculum teaching
3	Kong Lingjun's Villa (Residence of Kong Xiangxi's Second Daughter)	Residence of Kong Xiangxi's second daughter	Building information collection—architectural character recognition—spatial renewal design	To validate the digital conservation and presentation transformation model for wartime historical architecture
4	Kongyuan Administrative Building	Auxiliary building of Kongyuan	Auxiliary building surveying—functional reconstruction—integration of educational display	To validate the combined approach of adaptive reuse of auxiliary buildings and educational dissemination
5	Lin Sen Bathhouse	Cultural Relic Conservation Unit of Banan District	Collection of special-function spaces—scene reconstruction—narrative renewal	To verify the operability of digital reconstruction and immersive presentation for small-scale historical spaces
6	Weilu (Zeng's Mansion)	Cultural Relic Conservation Unit of Chongqing Municipality	Spatial surveying—architectural character extraction—integration of presentation and renewal	To validate the integrated approach of digital renewal and cultural dissemination for mansion-type historical buildings
7	Principal's Residence	Major Historical and Cultural Site Protected at the National Level	Archive review—digital modeling—narrative tour design	To verify the value of digital narrative and guided dissemination for buildings associated with historical figures
8	Zhulin Villa ("Two Chen" Residence)	Major Historical and Cultural Site Protected at the National Level	Integration of historical information—scene modeling—renewal expression	To validate the model of digital conservation and public dissemination for former residences of renowned individuals
9	Former Site of the Research Department of the Central Political School (Peng's Residence)	Major Historical and Cultural Site Protected at the National Level	Panoramic collection—digital exhibition hall construction—multimodal dissemination	To verify the feasibility of digital conservation and adaptive reuse for large-scale courtyard-style historical architecture

As can be seen from **Table 2**, the digital model samples from the Nanquan area exhibit three distinct characteristics: First, the samples are well-structured in terms of heritage classification and architectural types, encompassing both high-level protected objects such as Tingquan Building, Kongyuan, the President's Residence, and Bamboo Grove Villa, as well as ancillary or small-scale spaces like the Internal Affairs Building within Kongyuan and Lin Sen Bathhouse. Second, the samples extend from individual mansions to courtyards and ancillary buildings, enabling technical validation across different spatial scales. Third, most samples cater to the needs of Conservation, exhibition, renewal, and educational transformation, indicating that the objective of digital Conservation is not merely archiving but a comprehensive application oriented towards research, management, and public dissemination.

Figure 2 does not simply list the samples but attempts to illustrate the dual-dimensional relationship of "depth of Conservation—intensity of utilization". Objects such as the Tingquan Building, Kong Garden, Kong Lingjun's Villa, and the former site of the Research Department of the Central Political School are more suitable

for undertaking the composite task of "high-precision archiving + in-depth exhibition", while ancillary buildings are more appropriate as experimental samples for functional renewal and educational integration.

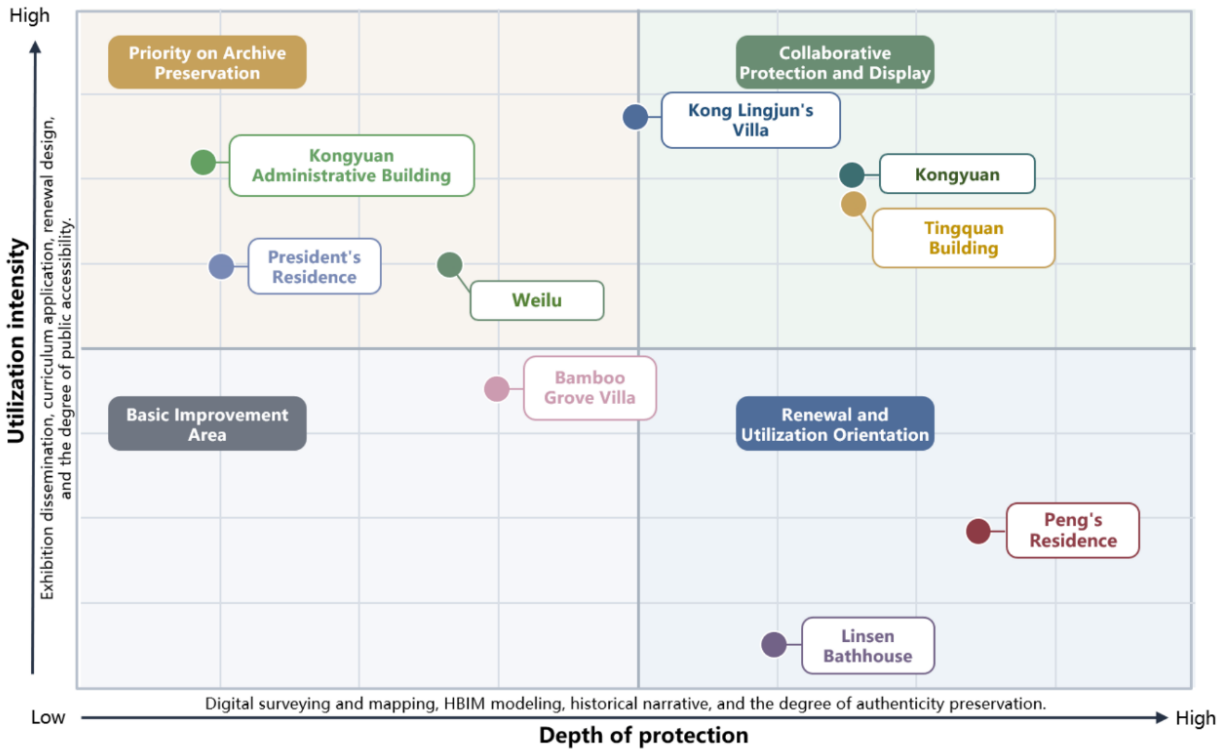

Figure 2. Schematic Diagram of the Digital Conservation Matrix for Representative Samples of Anti-Japanese War Historical Buildings in the Nanquan Area

Further analysis by building type reveals that mansions or former residences of celebrities, such as the Tingquan Building, Kong Garden, and Weilu, typically possess complete morphological characteristics and strong public recognition, making them suitable for a comprehensive approach involving "high-precision collection + HBIM modeling + immersive exhibition" to enhance narrativity and accessibility while preserving authentic information. Ancillary or small-scale buildings like the Kongyuan Administrative Building and the Linsen Bathhouse are more suitable for focusing on lightweight modeling, partial restoration, and educational exhibition. Large-scale courtyard-type objects, such as the former site of the Research Department of the Central Political School (Pengjia Courtyard/Peng's Residence), are more suitable for adopting an approach involving "overall scene reconstruction + multi-node guided tours + hierarchical information organization".

Overall, the case study of the Nanquan area demonstrates that digital Conservation does not equate to freezing the original appearance but rather connects spatial renewal with historical narration while respecting authenticity and recognizability. Digital models serve at least three functions: accurately expressing the original spatial layout, simulating the impact of different schemes, and enhancing public understanding and serving educational purposes.

5. Implementation mechanisms and optimization suggestions for the digital conservation of Anti-Japanese War historical buildings in Chongqing

First, a hierarchical and classified basic database should be established. Priority should be given to completing high-precision collection, HBIM modeling, and monitoring deployment for key samples at the municipal level and above, while general samples can initially undergo GIS positioning, panoramic collection, and basic archiving

before gradual upgrades. Second, HBIM should serve as the core data foundation, with 3DGS, panoramic tours, VR, and AR serving as lightweight expression layers for different audiences. Third, data standards and update mechanisms should be refined, with unified naming, coding, precision, and attribute fields, and a closed-loop process of "collection—modeling—review—publication—feedback" should be established. Fourth, school-local collaboration and curriculum integration should be strengthened to ensure that digital achievements take into account Conservation management, teaching practice, and public dissemination.

6. Conclusion

The key to the digital Conservation of Anti-Japanese War historical buildings in Chongqing lies not in technological accumulation but in constructing a reusable comprehensive framework centered on heritage authenticity, continuous renewability, and public accessibility. The path proposed in this article, "multi-source collection—Scan-to-HBIM—semantic enhancement—digital twin—multimodal dissemination", aims to incorporate authoritative archives, management decisions, and social dissemination into the same system.

From the typed analysis of digital model samples from nine buildings in the Nanquan area, it can be seen that the digital Conservation of Anti-Japanese War historical buildings in Chongqing already possesses a realistic foundation for transitioning from individual case experiments to system construction. Future efforts can still be deepened in directions such as component semantic standards, cross-platform interoperability, monitoring data feedback, AI-assisted annotation, and educational scenario integration, to promote the digital Conservation of Anti-Japanese War historical buildings in Chongqing from "visual exhibition" to "sustainable governance".

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References

[1] General Office of the Central Committee of the Communist Party of China, General Office of the State Council, 2022, Opinions on Promoting the Implementation of the National Cultural Digitalization Strategy, visited on 2022-05-22, http://www.scio.gov.cn/zdgz/jj/202309/t20230914_769253.html.

[2] Publicity Department of the Central Committee of the Communist Party of China, National Development and Reform Commission, Ministry of Education, 2021, Guiding Opinions on Promoting the Reform and Development of Museums, visited on 2021-05-25, http://www.scio.gov.cn/xwfb/gwyxwbgsxwfbh/wqfbh_2284/2021n_2711/2021n11y03rsw/wjxgzc_4238/202208/t20220808_315114.html.

[3] Banfi F, Liu W, 2026, The State of HBIM in Digital Heritage: A Critical and Bibliometric Assessment of Six Emerging Frontiers (2015–2025). Appl Sci, 16(2): 906.

[4] Zhang J, Zhang L, Zhao W, et al., 2025, HBIM for Protection and Management: A Case Study of Chinese Timber

Architectural Heritage. npj Herit Sci, 13: 399.

[5] Chen L, Dai C, Zhou M, et al., 2025, Development and Application of an HBIM Method for Timber Structures Integrated with Digital Technologies. npj Herit Sci, 13: 381.

[6] Banfi F, Cazzani A, Liu W, 2025, XR Technologies for Enhanced Cultural Engagement: From HBIM to Comparative Analysis of VR and WebVR Development Tools. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 48: 95–102.

[7] Niccolucci F, Felicetti A, 2024, Digital Twin Sensors in Cultural Heritage Ontology Applications. Sensors, 24(12): 3978.

[8] Hosamo H, Mazzetto S, 2025, Integrating Knowledge Graphs and Digital Twins for Heritage Building Conservation. Buildings, 15(1): 16.

[9] Yu Y, Verbree E, van Oosterom P, et al., 2025, 3D Gaussian Splatting for Modern Architectural Heritage: Integrating UAV-Based Data Acquisition and Advanced Photorealistic 3D Techniques. AGILE: GIScience Series, 6: 51

[10] Jamil O, Brennan A, 2025, Immersive Heritage Through Gaussian Splatting: A New Visual Aesthetic for Reality Capture. Front Comput Sci, 7: 1515609.

[11] UNESCO World Heritage Centre, 2025, Dive into Heritage, visited on 2025-08-04, https://whc.unesco.org/en/dive-into-heritage/.