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Enhancing the Interpretation of Industrial Heritage and Cultural Landscape of Iwami Ginzan through Digital Technologies

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Abstract

Iwami Ginzan, as a representative World Heritage site of Japan in the category of industrial and cultural landscapes, has multiple and diverse heritage elements that are rich in value but difficult to present as a whole. This study explores how digital technologies can enhance the interpretation of Iwami Ginzan's heritage values by analyzing challenges across three key dimensions: value recognition, information organization, and dissemination and presentation. Based on field investigations and the application of digital tools, the study proposes a three-tiered proposal: (1) constructing a virtual exhibition of the World Heritage Center to support pre-visit engagement; (2) positioning the Heritage Center as a narrative hub linking multiple heritage components; (3) utilizing various digital technologies to strengthen on-site interpretation. This study demonstrates the applicability of digital data acquisition tools and explores how museums and heritage sites can be digitally integrated through dissemination strategies. The findings offer both theoretical insight and technical references for future interpretation practices of cultural landscape heritage.

1. Introduction

1.1 Research Background

Iwami Ginzan, once the largest silver mine in Japanese history, is located in Oda City's Omori district and its surrounding areas in Shimane Prefecture (Figure 1). Silver extraction began during the 16 century and reached its peak in the 17 century. At its height, Iwami Ginzan accounted for one-third of the world's silver production. Due to a combination of various factors, the mine was closed in 1923, and the industrial facilities, streets, and buildings associated with silver production gradually fell into disuse and decay.

It was not until the 1970s that the government of Oda began systematic investigations into the historic streets and buildings of Iwami Ginzan. By the early 1990s, the basic structure of the heritage components had been identified, and preparations for World Heritage inscription began. In 2007, Iwami Ginzan was officially inscribed on the World Heritage List as a cultural landscape.

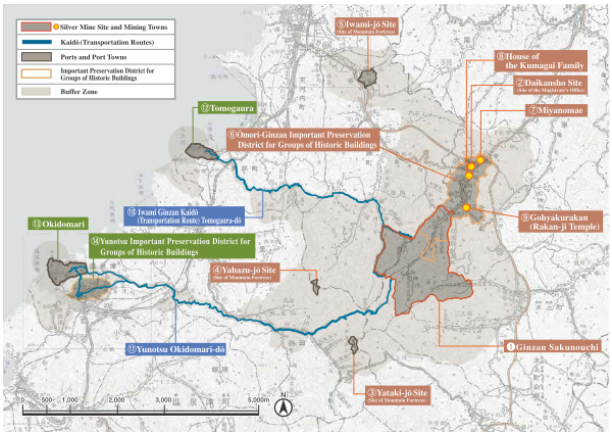

Figure 1. Heritage Distribution of Iwami Ginzan
(Source: https://ginzan.city.oda.lg.jp)

Following its inscription in 2007, the number of annual visitors to Iwami Ginzan reached 713,700, peaking at 813,200 in 2008. However, in recent years, this number has declined to 246,100. Although there has been a slight rebound following the COVID-19 pandemic, it remains less than one-third of the peak (Shimane Prefecture Tourism Promotion Division, 2023). Multiple factors contribute to this decline. According to visitor questionnaires and local feedback, the following issues are commonly cited: (1) monotonous and centralized tourism experience; (2) insufficient interpretive information; (3) inconvenient transportation; (4) short visitor stays; (5) limited number of international tourists (Iwami Ginzan Lifestyle Tourism Research Institute, 2022).

Against this backdrop of declining visitor numbers and a lackluster tourism experience, enhancing the overall quality of on-site engagement has become an unavoidable issue. In this regard, effectively conveying the historical background and cultural significance of the heritage site is an essential part of improving the tourist experience. This is especially true for Iwami Ginzan, a cultural landscape composed of diverse elements such as mining remains, sites, and historic streets. The diversity and geographical distribution of these heritage components make their organization and interpretation a considerable challnge.

1.2 Research Objectives

This study takes the cultural landscape values of Iwami Ginzan as its foundation and analyzes the current status of value interpretation for each type of heritage component. It identifies key shortcomings in the interpretation process and explores how digital technologies can be employed to enhance interpretive capacity across three dimensions: value recognition, information organization, and dissemination and presentation. Ultimately, the study presents a three-tiered proposal that positions the museum as an interpretive hub, linking it with on-site heritage sites to enhance the interpretation of Iwami Ginzan’s cultural landscape values.

2. Value Structure and Interpretation Status

2.1 Value Structure

As a cultural landscape heritage that embodies both natural and cultural, as well as tangible and intangible dimensions, Iwami Ginzan's value structure extends beyond the definitions set forth by the World Heritage framework. It encompasses a broader range of heritage contexts and intangible elements. Therefore, this study categorizes the value structure of Iwami Ginzan into three hierarchical levels (Figure 2).

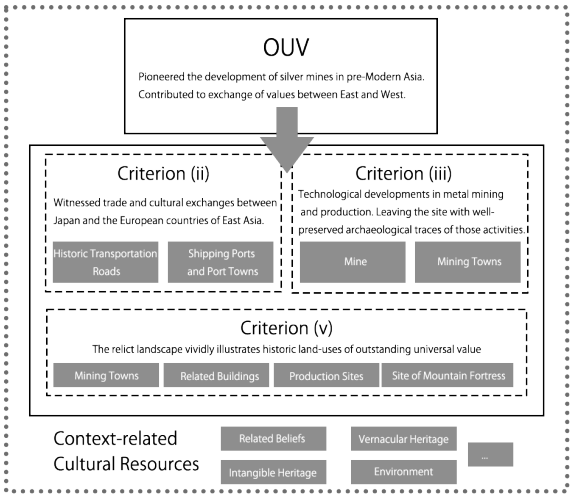

Figure 2. Value Structure of Iwami Ginzan

The first level is the Outstanding Universal Value (OUV) officially recognized by UNESCO: Pioneered the development of silver mines in pre-Modern Asia, Contributed to exchange of values between East and West.

The second level consists of the specific heritage components corresponding to the OUV criteria, including mining tunnels, archaeological sites, historic streets and buildings that constitute the cultural landscape.

The third level comprises context-related cultural resources, which include intangible heritage elements and unregistered tangible features that embody historical memory, technical knowledge, and patterns of production and daily life. These may involve mining techniques, associated belief, and historical environmental settings.

2.2 Current State of Value Interpretation

Heritage interpretation entails not only the accurate identification of a site's inherent values but also the use of multi-technical approaches to convey those values comprehensively. This section reviews the existing interpretation system of Iwami Ginzan, focusing on both on-site interpretation and museum-based interpretation. The aim is to examine which aspects of heritage value remain underexplored and whether the current technological tools adequately serve the purpose of value interpretation.

2.2.1 Mining Tunnels: Mining activities at Iwami Ginzan spanned over 400 years, resulting in a vast number of mining tunnels distributed across a wide area. However, the site experienced multiple closures and abandonments, particularly the complete cessation of mining operations in 1923, leading to most tunnels being submerged in the environment and rendered inaccessible for public viewing. Since the investigation of the Ryugenji Mabu tunnel began in 1988, research on the mining tunnels has continued for over three decades, documenting their locations, types, and assigning identification numbers to each.

At present, most of tunnels remain closed to the public. Only the Ryugenji Mabu tunnel is freely accessible, equipped with lighting at key locations such as ore veins, vertical shafts, and tool marks to aid visitor understanding. The Ōkubo Mabu tunnel, the largest among them, is accessible only by reservation and requires guided tours at designated times.

In summary, the interpretation of mining tunnels exhibits a concentration of interpretive resources in a few accessible locations, with limited variation in presentation methods. Most tunnels remain inaccessible, and visitor understanding often depends on guided explanations, making it difficult to directly experience the heritage value and significance of these industrial remains.

2.2.2 Archaeological Sites: The Archaeological sites can be broadly classified into production-related sites and castle ruins. The production heritage includes all the remains of the production chain, from the extraction of the mine to its processing and transportation. Among the former, the Shimizudani Silver Refinery Site reveals the use of a silver refining method during the Edo period. At this site, an AR-based mobile application has been implemented to reconstruct the refinery's historical appearance, including the architectural layout of the factory. Additionally, several sorting yards and religious-related remains can be found near the tunnel entrances. However, these are overgrown and in a neglected state, with poor accessibility, making their interpretive value difficult to convey.

The castle ruins, which were constructed to manage mining operations and ensure the site's security, are strategically located on mountain ridges or along important transportation routes. The value of these yamajiro (mountain castles) lies in their siting on steep terrain. Some, such as the Yataki Castle ruins, still retain stone walls and moats. However, they are physically separated from the main tourist areas, require strenuous hikes to reach, and are thus difficult to incorporate into interpretation efforts.

In summary, archaeological sites face multiple challenges in terms of value interpretation. Many are located in mountainous terrain with low accessibility, making visitation difficult. Furthermore, most remain as surface-level ruins with limited spatial legibility, making interpretation difficult.

2.2.3 Historic Streets and Buildings: The Iwami Ginzan World Heritage site includes two historic streets and two transportation routes. Ōmori was under direct shogunate control during the Edo period(17~19 centuries), while Yunotsu developed as a port town. Ōmori was designated as an Important Preservation District for Groups of Traditional Buildings in 1987, followed by Yunotsu in 2004. These streets retain numerous high-value architectural structures, some of which are listed as cultural properties. As living heritage environments, these streets and buildings are still inhabited, posing challenges to consistent interpretation.

Currently, two main interpretive methods are offered: guided group tours and self-guided exploration using maps such as the “Walking Map.” In the Ōmori Ginzan area, the town has been

divided based on its historical zoning into administrative, commercial-residential, and mining areas, with recommended routes and key interpretive stops. These stops include traditional residences converted into exhibition spaces, religious temples, and museums that convey the mining town’s historical narrative through a combination of architectural space and curated content. The streets are spatially continuous with the mining zones, creating a physical sequence from “administration” to “residence” to “production.”

The two transportation routes—Tomogaura Road and Yunotsu Okidomari Road—were once essential for transporting silver from the mines to the port. In the 1990s, these roads were surveyed for their heritage components, and signboards were installed at key locations. However, these routes have long since fallen into disuse, with only fragmented road remnants, temples, and transport-related ruins preserved. Today, only a few hiking enthusiasts traverse portions of these paths.

While the Ōmori and Yunotsu streets are the most popular destinations within Iwami Ginzan, several issues remain in their value interpretation. The current system lacks a structured interpretive framework and over-relies on visitor self-navigation in the absence of guided tours. Although Ōmori Street and the mining zone are spatially continuous, the interpretation of their values remains fragmented. The limited use of digital tools and the absence of interactive digital guides hinder the dissemination of information to unguided visitors. Additionally, as a living heritage site, many buildings are not accessible for public viewing, limiting opportunities to fully understand historical lifeways.

2.2.4 Context-Related Cultural Resources: In terms of context-related cultural resources, some progress has been made in interpreting intangible heritage elements. For instance, Iwami Kagura is regularly performed in Yunotsu on weekends and during local festivals. These performances, integrated with various community events, have successfully supported the transmission and public engagement of this intangible heritage.

In contrast, the interpretation of everyday vernacular life along the streets remains limited. In Ōmori Street, interpretive content primarily focuses on architectural styles, construction periods, and their relation to silver mining history, with insufficient attention to residents’ lived experiences and spatial memory. As a well-preserved historic townscape, Ōmori is itself a dynamic form of “living heritage.” Since the decline of mining, residents have continued to sustain local vitality. After the area’s designation as a preservation district, buildings have been progressively restored and adapted, reflecting shifts in lifestyle, demographics, and social needs. These transformations are integral to Iwami Ginzan’s value, yet they have not been adequately incorporated into the current interpretation system.

2.2.5 Interpretation at the Facility: The Iwami Ginzan World Heritage Center opened in 2008. In light of the site’s difficult internal transportation and the challenge of perceiving the full scope of heritage values solely through on-site visits, the Heritage Center was established as the first stop for visitors arriving at Iwami Ginzan. Functioning as a hub for value interpretation, the Center also serves as a central point for transportation coordination and on-site information access.

Within the Center, a variety of exhibition methods are employed, including original documents, scale models, informational panels, videos, and immersive VR-based learning programs, all designed to support visitors in gaining a multifaceted understanding of the site’s heritage.

Currently, in order to enhance the interpretive efficiency of the Heritage Center, a comprehensive content renewal and reorganization plan is underway. This update includes revising the exhibition content, relocating interactive devices, creating new thematic display zones, and expanding experiential learning opportunities, with the goal of making the center’s offerings more compelling and engaging. From the perspective of this study, however, there is still room for improvement in establishing stronger connections among the various interpretive components. For example, better digital linkages and interactive integration between exhibit items, physical models, and the actual archaeological sites could further strengthen the narrative coherence and immersive experience.

3. Constructing a System for Heritage Interpretation

3.1 Overview of Current Digital Transformation Practices

Figure 3. Current Digital Practices
Left: Metaverse Project, Right: 180° dome cinema

In 2021, Taisei Corporation launched the Iwami Ginzan Metaverse Project, aiming to build a “TwinVerse” system centered on digital twin technologies, integrating BIM, point cloud data, generative AI, and augmented reality (AR) for application at the Iwami Ginzan World Heritage site (Figure 3 Left). This TwinVerse platform merges physical heritage with digital space, enabling the reconstruction of historical environments, offering virtual heritage tours, facilitating multi-stakeholder narrative engagement, and supporting educational and public outreach efforts (Taisei Corporation, 2024).

The project employs a wide range of digital tools, including point cloud scanning, BIM, AI-generated dialogue, GIS-based data mapping, and XR (extended reality) visualization. Through community co-creation and integration with educational environments, it has constructed a heritage management, monitoring, and dissemination platform that is simultaneously visual, experiential, and interactive(Taisei Corporation, 2025).

Moreover, Iwami Ginzan has already adopted digital technology in its exhibitions to enhance interpretive experiences. For instance, the otherwise inaccessible Ōkubo Mabu tunnel is virtually presented through AR applications, VR headsets, and 180° dome cinema, offering immersive access to its interior (Figure 3 Right). In certain on-site locations, such as historic building ruins, visitors can scan QR codes on their smartphones to experience AR reconstructions of the original architecture.

	Museum	Mining Tunnels		Archaeological Sites		Streets and Buildings		Context-Related Cultural Heritage
		Accessible Tunnlels	Closed Tunnels	Mining Sites	Fortress Sites	Historical Streets	Traditional Group of Buildings	
Value Recognition	–	–	Low awareness of value	Some sites undocumented	Sites partially known but undervalued	–	–	Cultural boundaries vague; further study needed
Information Organization	Weak link between exhibitions and physical sites	Weak connection to Ōmori streets	Mentioned but unclear	Weak connection with street networks	Limited records, unclear structure	Disconnected from transportation context	Disconnected from production history	Often unclassified or intangible; requires thematic contextualization
Dissemination & Presentation	Lacks multi-perspective storytelling; limited interaction	Digital tools used for immersive experience	Mostly inaccessible; reliant on guided tours	Some sites visible, but few interpretation aids	Lack of presentation tools	Relies on guidebooks and signage; weak visitor engagement	Limited public access; static presentation	Limited use of media; mostly traditional or text-heavy

Table 1. Hierarchies in Value Interpretation

3.2 Hierarchies in Value Interpretation

Undeniably, existing digital initiatives and exhibitions at Iwami Ginzan have adopted a range of technologies, which have expanded the boundaries of value interpretation to a certain extent. Based on the current state of heritage interpretation and drawing from technologies already in use, this study proposes a more systematic interpretive framework to identify the weak links in each interpretive phase and to formulate targeted strategies that leverage digital technology to enhance interpretive capacity.

From a technical perspective, the heritage value interpretation process can be structured into three major steps: value recognition, information organization, and dissemination and presentation. Value recognition involves not only scientifically validated methods for identifying the values of a heritage site, but also includes any supportive actions such as conservation, restoration, and reconstruction that contribute to making those values perceptible and communicable (Australia ICOMOS, 2013). Information organization refers to the structuring of internal logical and historical relationships among heritage components—an especially crucial step for industrial heritage, which typically consists of diverse and complex components. Dissemination and presentation includes two dimensions: interpretive strategies and communicative media. Interpretive strategies involve the narrative structuring and contextual translation of heritage content for public audiences, while communicative media comprise the technological tools, devices, facilities, and spatial configurations that support the interpretive process and link various components of the heritage landscape (ICOMOS, 2008).

Drawing upon the issues identified in the current interpretation system and integrating available digital technologies, this study outlines the present condition of Iwami Ginzan’s interpretive practices across the three dimensions.(Table 1)

4. Three-Tiered Proposal for Enhancing Heritage Interpretation at Iwami Ginzan

To enhance the interpretation of heritage values, it is first essential to clarify the typical sequence by which visitors experience cultural heritage sites. By aligning the interpretive hierarchy with this visitor pathway and integrating appropriate digital technologies, the overall experience and interpretive efficiency can be optimized. The standard visitor journey typically consists of: (1) online research and itinerary planning; (2) museum visits; (3) on-site exploration. (4) seeking additional information based on interests developed during the on-site visit. In response to this sequence, this study proposes an interpretive proposal that aligns with each stage of the visitor experience: offering pre-visit previews and post-visit learning opportunities online. On-site interpretation is centered around the World Heritage Center, and a network of heritage sites is linked via integrated storytelling strategies.

4.1 Online Pre-Visit

Web-based platforms serve as an accessible and far-reaching medium for potential visitors, capable of delivering a wide array of information tailored to user needs. They can support visitors in the planning phase by offering core heritage information, while also supplementing with practical guidance on transportation, dining, and tourism services. For individuals interested in the heritage itself, the platform functions as an educational tool, encouraging future site visits. In addition, after the visit, the platform can continue to serve as a resource hub for researchers and students seeking more detailed information.

To bridge online and on-site experiences, this study employs the Matterport Pro3 3D camera and Matterport Discover platform to construct a cloud-based digital museum. Matterport offers a comprehensive and practical solution for the digital management of cultural heritage, utilizing 3D LiDAR camera technology to simultaneously capture point cloud data and high-resolution imagery for both indoor and outdoor spaces, automatically generating spatial models. These models support embedded interpretive content, such as text, images, and videos. (Bocconcino et al., 2024). Once uploaded to the Matterport Discover platform, the lightweight data can be easily accessed via mobile or desktop web browsers (Figure 4).

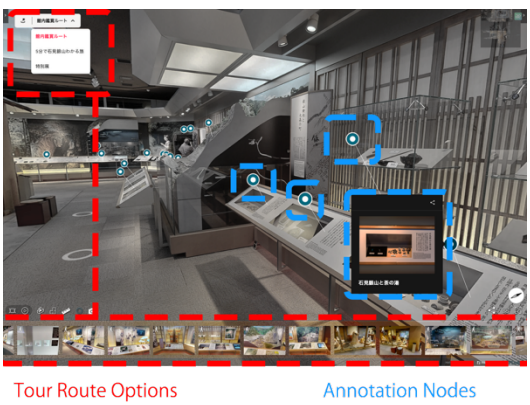

Figure 4. Online Exhibition via Matterport Discover Platform

In terms of information organization, the first step involves collecting diverse data types from the museum. Using the Matterport Pro3, spatial data of each exhibition gallery can be captured. High-resolution images of displayed artifacts and panels are taken with digital cameras. Photogrammetry

techniques are employed to document the forms of detailed physical models. These materials are then edited within the Matterport Discover platform, integrating onsite images, 3D models, and publicly available information to build a comprehensive online museum. Matterport supports the insertion of annotation nodes at any point within the 3D model, each capable of containing multimedia content such as images, videos, and links. This feature allows for dynamic extensions of static panels—for example, turning an informational board into a video explanation or offering comparative views between historical and present-day conditions. Complex processes that are difficult to explain through text can instead be conveyed via embedded video walkthroughs.

In terms of dissemination and presentation, the Matterport platform allows for the creation of customized tour pathways targeting different audiences based on background, age, and language. Suggested categories for tour design include: (1) School-aged children – emphasizing visual storytelling while avoiding dense text; (2) General visitors – retaining main panel content, supported by voice and video narration to create an interactive “listen–view–click” experience; (3)Foreign language users – offering multilingual options with simplified content, avoiding jargon; (4) Researchers and educators – including detailed information on excavated artifacts, historical archives, and explanations of technical terms.

Temporary exhibitions can also be recorded and archived digitally for future reference and educational reuse. Furthermore, the design of interpretive content should deliberately retain a degree of mystery—by withholding certain details or suggesting unresolved questions—to stimulate the visitor’s curiosity and motivate an on-site visit.

The final step is remote integration: embedding the Matterport platform directly into the official website of the Iwami Ginzan. This allows the content to reach a wider audience, significantly expanding the scope and impact of information dissemination.

4.2 Digital Spatial Reorganization within the Museum

As the first point of contact for visitors entering the heritage site, the Iwami Ginzan World Heritage Center serves as a vital nexus linking knowledge with physical experience. It plays a foundational role in establishing a cognitive framework that connects the various heritage components. Therefore, the center must provide structured, overarching knowledge that facilitates value recognition.

First, from the perspective of information organization, during exhibition renewal or the addition of new experiential spaces, the digital model generated through Matterport scanning can be utilized in combination with the Matterport Discover platform and MPEmbed, a customizable embedding tool. This enables a form of structural digital reconstruction of interpretive content. Specifically, the Matterport model contains depth data, allowing for basic spatial measurements of gallery areas such as room dimensions, distances, and fields of view. By integrating these spatial data with exhibition design considerations, planners can explore adjustments to display panel heights, visitor circulation routes, and spatial relationships between panels and artifacts. Additionally, MPEmbed can also be used for virtual exhibition previews during the planning stage.

Second, in terms of dissemination and presentation, dedicated experiential areas can be established within the museum to present digital models of historic streets, mining tunnels, and surrounding environments through interactive displays. Given the physical limitations of the museum in adding entirely new exhibit zones, existing diorama models can be adapted into interactive touch-based displays (Zaharias et al., 2013). In this configuration, visitors can interact with icons embedded in the model to trigger related content. Unlike traditional static dioramas, these interactive models can incorporate a temporal dimension and link various heritage assets, enhancing narrative complexity.

Furthermore, the existing VR experience zone can be updated to offer access to currently inaccessible heritage components. These might include mining tunnels, historic buildings, and transportation routes that are difficult to reach in person, as well as immersive presentations of intangible cultural heritage.

In addition to creating dedicated digital experience zones, AR technologies can be employed to overlay digital content directly onto physical artifacts, thereby enhancing visitor engagement. For instance, by recognizing an object’s form or scanning a QR code, users can access digital augmentations such as reconstructions of the artifact’s original appearance, contextual background information, animations, or multilingual guided tours (Patti, 2020). This approach strengthens the sense of interaction between visitor and artifact while mitigating the fatigue often associated with reading large blocks of text.

4.3 Enhancing On-Site Interpretation of Heritage

4.3.1 Mining Tunnels: As industrial heritage, mining tunnels represent the most fundamental and symbolic component of Iwami Ginzan’s historical value. In this study, a point cloud survey was conducted on the publicly accessible Ryūgenji Mabu tunnel. Leveraging the adaptability of Mobile Mapping Systems (MMS) to complex and confined environments (Malinverni et al., 2018), a geomatic survey was completed within a short timeframe, covering 150 meters of the tunnel interior and capturing both geometric data and coordinates (Figure 5).

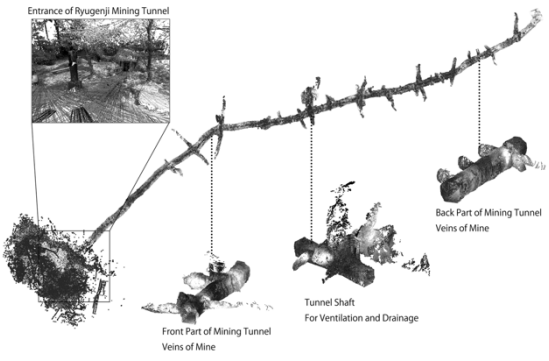

Figure 5. Point Cloud of Ryūgenji Mabu Tunnel

The point cloud model of the tunnel offers significant contributions across all three interpretive dimensions: (1) In terms of value recognition, the spatial and structural characteristics captured through point cloud data help clarify the physical attributes and intrinsic significance of the mining tunnels. Using MMS, the internal surface geometry of the tunnels can be rapidly recorded, allowing for an accurate digital reconstruction of the tunnel space. This facilitates a comprehensive understanding of the tunnels’ historical value by enabling distinction between various sub-tunnels from a three-

dimensional perspective. (2) For information organization, large-scale point cloud acquisition of the tunnels and their surrounding environment enables typological analysis based on parameters such as site location, period of excavation, functional classification, and mining techniques. This allows for the construction of a more systematic genealogical framework of tunnel types and mining practices within Iwami Ginzan. (3) Regarding dissemination and presentation, point cloud data can be processed through mesh generation and texture reconstruction to produce VR-compatible models. These models can be incorporated into exhibitions at the World Heritage Center or featured in online virtual displays. This digital visualization effectively addresses the issue of physical inaccessibility for most tunnels, while also supporting structured narrative integration with museum content.

4.3.2 Archaeological Sites: The Iwami Ginzan region contains a wide variety of archaeological sites, differing significantly in terms of spatial distribution, functional attributes, and preservation status. Some have been prepared and opened to the public, while others remain hidden deep within the mountains and forests, largely unknown to visitors. Compared to more visually concrete forms of heritage such as historic streets and buildings, these sites generally lack clearly defined physical structures, making their value recognition and dissemination more dependent on digital reconstruction and immersive visualization techniques.

This study selects the area in front of the Ryūgenji Mabu tunnel as a case study to explore how point cloud technology can enhance the interpretation of archaeological sites. The scanned area is located along the mountain path that connects Ōmori Street (the mining town) to the tunnels, forming a critical spatial link between the residential zone and the mining area. However, due to long-term overgrowth by dense forest and vegetation, this area—containing elements such as tunnel entrances, a mountain shrine, and work platforms—has become difficult to discern, making it challenging for visitors to perceive a spatial continuity from settlement to mine.

To address this, the study again employed MMS to conduct a three-dimensional survey of the area, aiming to capture a comprehensive dataset of the terrain and vegetation. In post-processing, CloudCompare was used to denoise the point cloud, and vegetation was removed using a combination of the CSF (Cloth Simulation Filter) and manual editing (Figure 6).

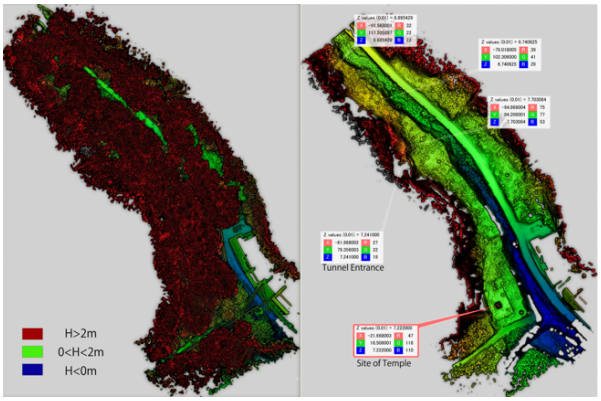

Figure 6. Comparison of Raw and Denoised Point Cloud Data in Front of the Ryūgenji Mabu Tunnel

The processed point cloud revealed multiple discernible features such as tunnel entrances, foundations, and stone lanterns (as shown in the figure). The MMS-generated high-precision point cloud provides detailed elevation and locational information for each of these heritage elements.

This study confirms several contributions of the method: (1) In terms of value recognition, MMS-based scanning serves as a non-invasive method that allows for the rapid and comprehensive capture of spatial data, offering an effective alternative to traditional excavation. This enables the identification of the spatial distribution of site components and clarifies how terrain and topography were utilized historically; (2) For information organization: The spatial relationships between heritage components can be clarified using the point cloud data, providing a foundation for structuring interpretive content and supporting typological or spatial analyses. (3) Regarding dissemination and presentation, the high-resolution point cloud provides precise geometric data for digital reconstruction. Based on this, accurate heritage site models can be developed and embedded into mobile XR applications. Visitors can then use mobile phone to scan the QR code and experience reconstructions of historical scenes on site.

4.3.3 Historic Streets and Buildings: Ōmori Street and its surrounding architectural cluster represent one of the core heritage elements of Iwami Ginzan. The area preserves traditional residences, merchant shops, and religious facilities dating back to the Edo period, embodying the daily living environment of miners and residents. However, compared to industrial components such as mining tunnels, the interpretive structure of the streets remains somewhat isolated; their functional linkage to mining and transportation activities is not clearly articulated in existing exhibits. Furthermore, as a living heritage site with a significant number of current residents, many buildings are not open to the public due to privacy and management concerns. This limited accessibility restricts both the coverage and depth of interpretation strategies.

To address these challenges, this study employed photogrammetry and the Matterport 3D camera to document the Koma-no-Ashi area of Ōmori street. The goal was to explore how digital technologies can reconstruct visual experiences and extend interpretive capacity without intruding upon residents’ privacy (Figure 7).

For the streetscape survey, a Sony camera with a wide-angle lens was used. Images were captured under overcast skies to minimize shadow interference and enhance texture quality. The surveyed segment covered approximately 90 meters of street, featuring traditional two-story wooden houses with characteristic gabled roofs. Control points were established on-site, and a Drogger GNSS receiver was used to record geolocation data for subsequent model calibration. Approximately 500 photos were captured, and the dataset was processed using RealityCapture to perform image alignment, 3D reconstruction, and georeferencing. The final deliverable was a mesh-based 3D model optimized for exhibition.

Photogrammetry presents two major advantages in this context: 1. Compared to laser scanning methods (TLS, MMS), it better preserves texture maps and surface details of traditional wooden architecture; 2. The high-resolution models can be simplified into low-polygon versions while retaining texture quality, making them suitable for online platforms and VR deployment.

Figure 7. Workflow for Enhancing the Interpretation of Historic Streets and Buildings

For interior documentation, Matterport camera was used to scan the interior of non-public traditional houses, resulting in an interactive, web-accessible virtual walkthrough. This compensates for the physical limitations of in-person visitation. Features such as interactive tags, voice guidance, and embedded multimedia enhance the interpretive diversity of these otherwise inaccessible spaces.

From the perspective of value interpretation, this study demonstrated several contributions: (1) In value recognition, the digitized streetscape model enables comparison with historical architectural drawings to track spatial transformations over time, revealing the intrinsic value of vernacular heritage shaped by local life. (2) In information organization, the street models can be incrementally expanded to link residential and mining zones and to integrate both outdoor and indoor spaces into a unified narrative structure. (3) In dissemination and presentation, the models can be exhibited in museum-based interactive displays, incorporated into VR experiences that reconstruct historical environments, or used for on-site AR-based scene re-creations.

4.3.4 Enhancing Heritage Interpretation Through Mobile Applications: Compared to the spatial limitations of indoor environments, heritage sites offer significant potential for immersive interpretive experiences. This study suggests a mobile application-based strategy as a possible approach to enhance such experiences.

A mobile app could be designed to allow users to access images, videos, 3D models, and other digital resources, thereby supporting a more stable and informative on-site visit. It may incorporate AR-based features to enable the visualization of historical scenes-particularly useful for archaeological sites-where visitors might scan QR codes to reconstruct past environments. In addition, gamification elements, such as exploration-based challenges or timeline-based puzzles, could be introduced to promote active engagement and self-guided learning (Çetin and Erbay, 2021).

Beyond serving as a supplement to traditional guidebooks and brochures, a mobile app might also function as a context-aware platform for delivering detailed, personalized content during the visit. Prior to arrival, users could select their personal interests, age group, and thematic preferences, which the app would then use to suggest exhibition highlights linked to relevant heritage information. The app could further generate customized touring routes (Vrettakis et al., 2023), offering guidance on transportation, shopping, and cultural experiences. Such an approach may contribute to a more integrated visitor experience that combines value interpretation, spatial navigation, and recreational elements.

5. Conclusion

This study has addressed the core question of how digital technologies can enhance the interpretation of cultural heritage values, focusing on the World Heritage site of Iwami Ginzan. Based on an in-depth examination of the site’s diverse heritage elements and current interpretive mechanisms, the research analyzed the practical challenges encountered across three critical stages of interpretation: value recognition, information organization, and dissemination and presentation.

In response, the study proposed a three-tiered proposal through the integration of digital data acquisition and digital exhibition methods: (1) Utilizing the Matterport platform to capture and construct an online virtual museum for the World Heritage Center, serving as an entry point for information dissemination and preliminary interpretation; (2) Employing high-precision 3D models within the Heritage Center to virtually redesign existing exhibition content and enrich interpretive layers using AR and VR technologies, thereby providing a multi-modal and interactive display experience; (3) Deploying a mobile application to integrate interpretive content across dispersed heritage locations, using digital technologies such as MMS, photogrammetry, and 3D LiDAR cameras to document unprepared heritage sites and tunnels, and to collect detailed geometric data for already conserved elements, thereby enhancing their expressiveness and narrative clarity (Figure 8).

Ultimately, this approach outlines a visitor-centered interpretive system structured around a sequential experience of online engagement – museum understanding – on-site exploration, with the museum acting as the interpretive hub connecting both physical and digital heritage environments.

Despite these initial proposals for technological pathways and operational mechanisms, the study acknowledges several limitations. First, a comprehensive understanding of Iwami Ginzan’s existing interpretation system is constrained by the lack of systematic visitor surveys and user experience evaluations, making it difficult to quantitatively assess the effectiveness of current strategies. Second, the digital tools employed in this study are largely general-purpose technologies that have not been specifically optimized or customized to suit the unique characteristics of heritage interpretation. Third, heritage interpretation is inherently influenced by epistemological perspectives and stakeholder negotiations. Information integration between the heritage site and the museum is often limited by issues such as ownership rights, administrative jurisdiction, and inter-institutional coordination,

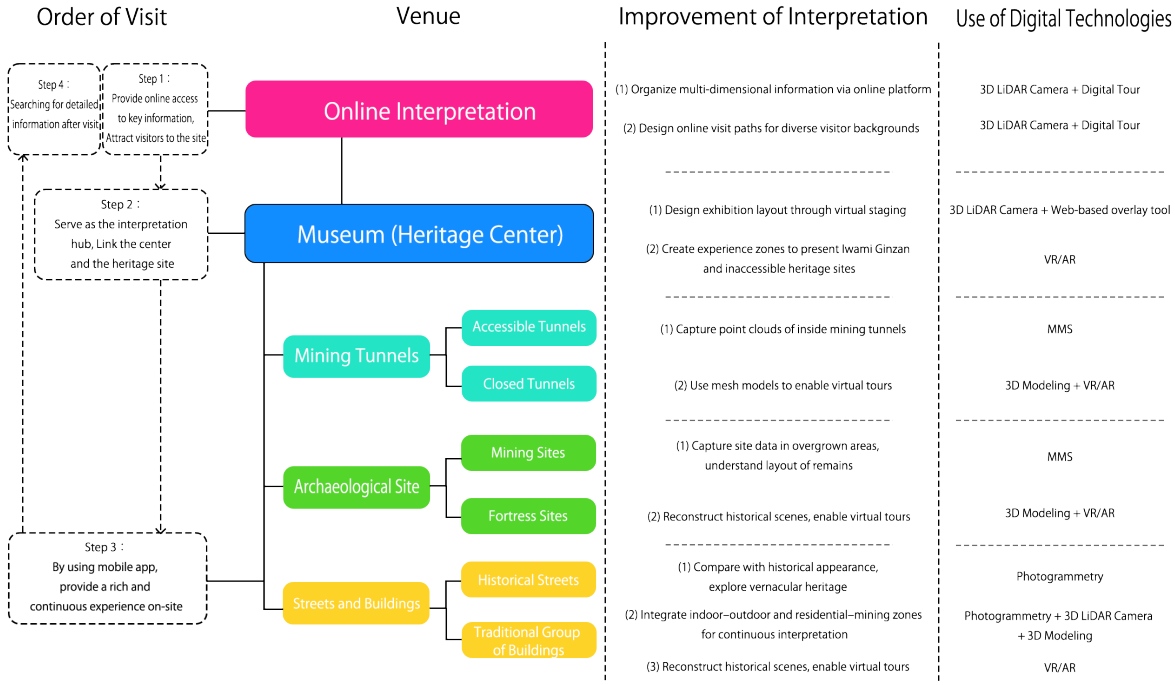

Figure 8. Three-Tiered Proposal for Enhancing Heritage Interpretation at Iwami Ginzan

all of which require more systematic responses through socio-technical collaboration mechanisms in future research.

Nonetheless, just as Iwami Ginzan’s historical significance has not remained static but has evolved through continuous research, excavation, and dissemination, so too must the heritage interpretation system be conceived as a process-oriented and sustainably evolving endeavour. Through the ongoing convergence of digital technologies and interpretive planning, not only can existing values be more deeply conveyed, but previously overlooked heritage components may be re-recognized and newly appreciated.

Looking forward, this study envisions a future in which broader user research, more advanced technological development, and diversified content strategies contribute to building a truly networked and spatially-integrated interpretive framework. Such a system would enable the cultural values of Iwami Ginzan to be continuously updated and revitalized—understood, appreciated, and inherited by present and future generations.

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