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# A Paradata Framework for Evidential Transparency in the Three-dimensional Virtual Reconstruction of Cultural Heritage

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**Abstract**

This study presents a paradata framework for evidential transparency in the three-dimensional virtual reconstruction of cultural heritage. By integrating the principles of the London Charter and Seville Principles with Dublin Core, CIDOC CRM, PROV-O and FAIR Principles, the framework supports transparent documentation of evidence sources, interpretative decisions, uncertainty, and reconstruction processes. Structured around a five-phase workflow record, a phase-based decision log, and a C1–C4 evidence classification system, the framework was demonstrated through two contrasting case studies involving SfM photogrammetry and handheld structured-light 3D scanning. This framework establishes a practical foundation for interoperable and reproducible 3D heritage documentation, with potential applications in AI-assisted reconstruction workflows and long-term digital preservation.

## 1. Introduction

The increasing use of 3D virtual reconstruction in cultural heritage has established it as a standard digital documentation method. However, evidential transparency remains challenging because evidence-based and inferred elements are often obscured, creating unwarranted certainty that compromises the London Charter's principle of intellectual transparency [1], [2]. To address this issue, this study proposes a workflow-based paradata framework that records evidence, provenance, interpretive reasoning, uncertainty, and reliability assessments using international standards in 3D virtual reconstruction.

## 2. Materials and Methods

The framework was developed by mapping international standards to their documentation functions: The London Charter and Seville Principles guide transparency, paradata, interpretation, and uncertainty recording, Dublin Core for descriptive metadata, CIDOC CRM and PROV-O record actors, sources, events, provenance, and data transformation while FAIR Principles for repository reuse and interoperability. These functions then structured into five phases: pre-acquisition, 3D data acquisition, data processing, virtual reconstruction, and output/archiving. The finalized framework consists of a five-phase workflow record, a phase-based paradata decision log, and a C1–C4 evidence classification system. Two case studies were tested: SfM-photogrammetry reconstruction of the stone-walled Yeonji pond and 3D handheld scanning restoration of Dokdo sea lion cervical vertebrae.

**Poster**

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**Table 1.** *C1-C4 Evidence Classification Guideline*

| Class | Decision Criterion | Confidence Sub-level | Example |
|---|---|---|---|
| C1 | Directly captured data | **High:** Complete/ **Medium:** Minor noise/**Low:** Incomplete or unclear | Scan surface |
| C2 | Restored from surviving references | **High:** Strong reference/ **Medium:** Partly uncertain/ **Low:** Weak reference | Mirrored anatomy |
| C3 | Indirect sources | **High:** Sources agree/ **Medium:** Limited evidence/ **Low:** Mostly interpretive | Archival photos |
| C4 | No reliable evidence | Not applicable | General analogy |

**Table 2.** *Comparative Case-Study Application and Representative Phase-Based Paradata Decision Log.*

| Case Study | Workflow Phase | Decision Record | Evidence Source | Uncertainty Record | Evidence Classification |
|---|---|---|---|---|---|
| Yeonji Pond | Data Processing | Photos brightness and contrast were adjusted | 88 Digital photos | Uneven photo quality may affect alignment accuracy | C3-Medium |
| Dokdo Sea Lion | Virtual Reconstruction | Missing part was mirrored from the opposite side | Right inferior articular process 3D scan data | Depends only on anatomical symmetry | C2-High |

## 3. Results and Discussion

The case application shows that the framework can record technical processes and interpretive decisions (refer Table 2), extending conventional metadata by preserving the reasoning and confidence behind reconstruction decisions. These fields can be stored as database records or exported as JSON-LD/RDF so that the evidence, reconstruction process, and uncertainty level remain searchable and reusable with the final 3D model. Future work should adapt the framework to AI-assisted reconstruction by defining fields for input data, model versions, prompts, generated alternatives, and human selection.

## 4. Conclusion

The proposed paradata framework supports evidential transparency in 3D virtual reconstruction by enabling careful and thorough documentation. While full system-level implementation remains a future task, the framework provides a practical foundation for interoperable repositories, AI-assisted reconstruction workflows, and long-term digital preservation.

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