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DIGITAL TWIN & MEMORY TWIN: THE NEW ARCHITECTURE OF KNOWLEDGE OFFICIAL INTERVIEW FOR THE CY2026EU DIGITAL HERITAGE SUMMIT

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In the context of the 2026 Digital Heritage Summit organized in Cyprus during the CY2026EU Presidency of the EU Council, how does the newly developed digital twin align with the broader scientific agenda for advancing methodological rigor, transparency, and reproducibility in digital cultural heritage research?

The newly developed Digital Twin / Memory Twin aligns strongly with the broader scientific agenda of methodological rigor, transparency and reproducibility because it shifts the focus from the production of a 2D/3D digital representation towards the documentation of the entire evidence-generation process. By integrating data, metadata, paradata and provenance, the Twin records not only what has been digitised, but also who, how, when, why, where and under which methodological conditions the digital representation was created. This enables researchers to assess quality, understand uncertainty, trace interpretations and, where possible, reproduce or audit the workflow. In this sense, the Twin operationalises the principles emerging from the EU VIGIE 2020/654 work on quality in 3D digitisation, particularly the recognition that quality cannot be separated from the complexity and documentation of the acquisition and

processing process.

More importantly, the approach positions the Digital Twin as an interoperable research object rather than simply a visualisation. Its combination of 3D data, metadata, paradata, provenance and knowledge supports FAIR and reusable digital scholarship while making uncertainty and interpretative decisions more



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explicit. This is particularly important in an era of AI-assisted reconstruction and analysis, where researchers must be able to distinguish measured evidence from processing, interpretation and generated content. The Digital Twin therefore becomes not only a representation of cultural heritage, but a transparent and traceable record of the scientific process through which knowledge about that heritage is constructed. In this sense, the next generation of Digital Twins should not only

reproduce 3D heritage objects, they should reproduce also the evidence, knowledge, values. Identity and methodological decisions that allow us to trust what those objects represent and have to transfer and tell us and here is the research area where we are actively involved: We extend and advance the Digital Twin to a Memory Twin.

Could you elaborate on the technological architecture and methodological principles underpinning the digital twin, particularly in relation to data acquisition, semantic enrichment, and the integration of paradata for ensuring scientific accountability?

The technological architecture of the Digital Twin / Memory Twin can be understood as a layered evidence-to-knowledge system rather than simply a 3D visualisation platform. It integrates multi-media and multi-modal data acquisition with digital representation, semantic enrichment, knowledge modelling and an explicit paradata & provenance layer. The acquisition layer captures not only geometry but also the conditions, instruments, parameters and quality of the observation process. Semantic enrichment then connects the resulting representations with historical, architectural, archaeological and intangible cultural

knowledge. Paradata provides the critical accountability mechanism by documenting how, when, why and by whom data and interpretations were produced or transformed (A certificate of Quality). Consequently, every digital representation, interpretation or AI-assisted reconstruction can remain connected to its underlying evidence and methodological history.

The fundamental principle is therefore that the Twin should preserve not only the digital surrogate of heritage, but also the chain of evidence and human decisions through which that surrogate, and the knowledge derived from it and why it was created.

Digital twins are increasingly regarded as epistemic instruments rather than mere visual surrogates. How does this shift influence the ways in which scholars interpret, validate, and disseminate knowledge about cultural heritage assets?

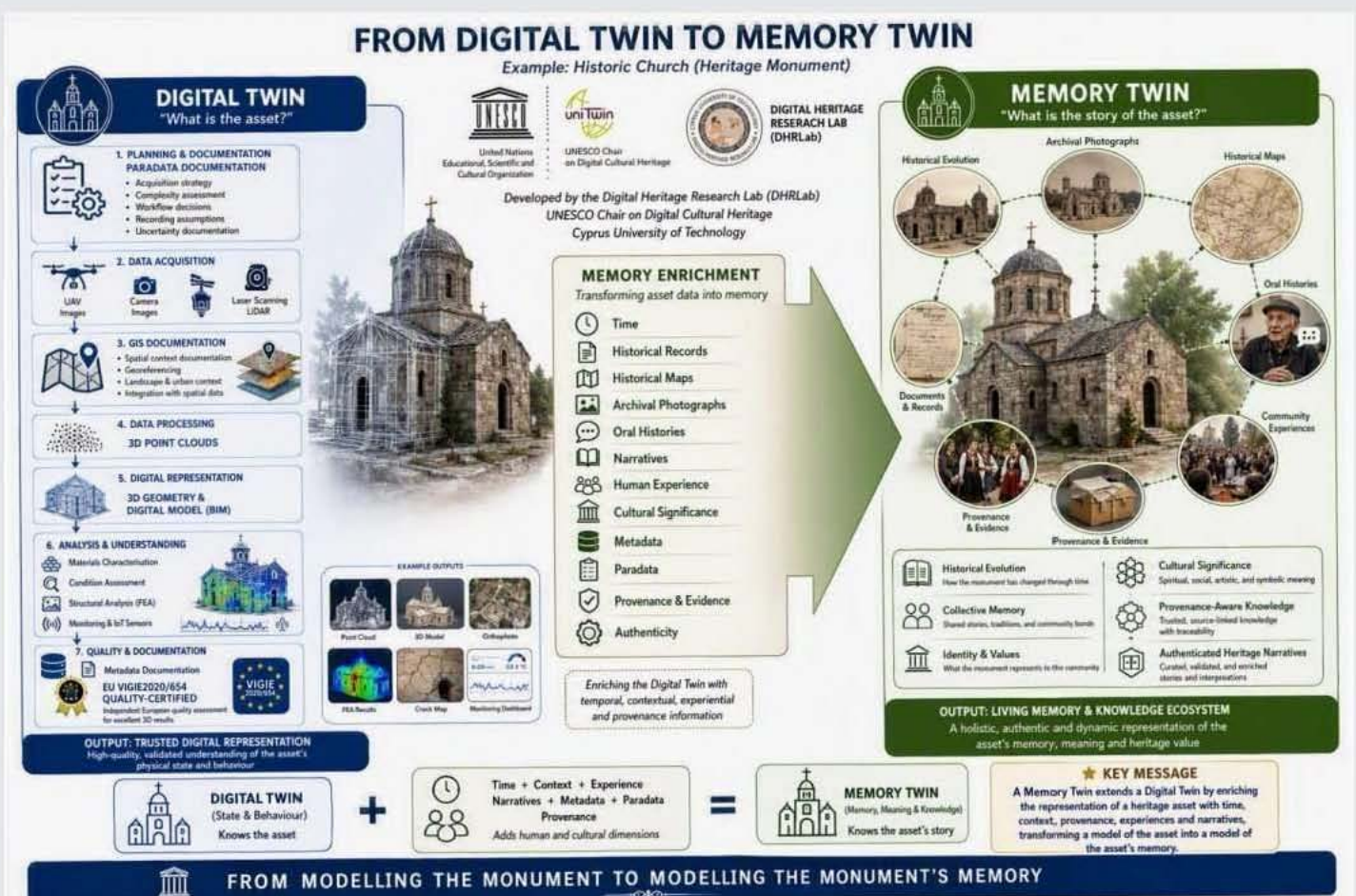
The 3D Digital Twin itself remains fundamentally a geometrical and spatial representation of the physical

tangible heritage asset. Its epistemic value therefore derives not only from transforming the geometry into historical knowledge (for example, by adding the materials used, their current condition and their chemical composition, the production technology, etc.), but also from the current scientific rigour with which that geometry is acquired, processed, validated and documented. The Digital Twin can consequently serve as a reliable evidential foundation for subsequent scholarly interpretation. The transition from geometrical, mechanical, structural representations to knowledge occurs when the Digital Twin is connected with metadata, paradata, provenance and contextual information within a broader Memory Twin framework. *In this architecture, the Digital Twin provides the geometrically accurate representation, while the Memory Twin connects that representation to the evidence, knowledge, narratives, identity and human values associated with the heritage asset.*

What ethical frameworks and governance models should guide the creation, curation, and long-term stewardship of digital twins, especially when dealing with vulnerable, contested, or politically sensitive heritage?

The ethical governance of Digital Twins in Cultural Heritage should be based on a combination of scientific quality, FAIR and CARE principles, provenance, IPR management and long-term stewardship. FAIR provides the foundation for making digital heritage resources Findable, Accessible, Interoperable and Reusable, while CARE adds the essential human and cultural dimensions of Collective Benefit, Authority to Control, Responsibility and Ethics. This distinction is particularly important for vulnerable or contested heritage, where openness cannot automatically mean unrestricted access.

In our approach, quality certification is an additional critical component. The Digital Twin as well as all other



multimedia data (storytelling, visual material, text, images, etc.) should be accompanied by documented evidence of the quality of its acquisition and processing, including geometric accuracy, completeness, resolution, uncertainty, provenance and methodological parameters. Such certification should concern the quality and traceability of the digital documentation, and should not be confused with certification of historical interpretation. This distinction is fundamental for scientific accountability.

For contested heritage, the Digital Twin should remain a scientifically documented geometrical representation, while the Memory Twin provides the broader knowledge environment in which evidence, provenance, historical sources, scholarly interpretations and community perspectives can be connected. Different types of knowledge should remain explicitly distinguished rather than being merged into a single authoritative narrative. Finally, governance should be participatory and distributed. The multi- / interdisciplinary user community such as heritage institutions, researchers, students, tourists, communities, policy makers, custodians and other legitimate stakeholders should have clearly defined roles in determining access, reuse and stewardship. Long-term preservation, versioning, persistent identifiers, provenance and periodic reassessment should be considered part of the ethical responsibility from the beginning. In this sense, responsible Digital Heritage is not simply about preserving digital representations; it is about preserving them with quality, provenance, accountability, cultural responsibility and respect for the communities to whom the heritage belongs.

How does the digital twin presented at the Summit

contribute to the development of interoperable, cross-border research infrastructures, and what potential do you see for its integration into European or global heritage data ecosystems?

The Digital Twin presented at the Digital Heritage Summit in Cyprus should be understood not as an isolated 3D repository or platform, but as an interoperable digital research object capable of participating in distributed European and global heritage infrastructures. Its contribution begins with the standardisation of the digital representation itself and extends to interoperable metadata, persistent identification, provenance, paradata, quality certification and machine-readable access mechanisms.

This approach is fully aligned with FAIR principles: Digital Twins should be Findable, Accessible under clearly defined conditions, Interoperable across technological and institutional boundaries, and Reusable through adequate documentation of provenance, quality and rights. CARE principles are equally important when the data concern vulnerable, contested or culturally sensitive heritage. Interoperability therefore should not mean unrestricted access, but responsible and governed interoperability.

A particularly important element is the integration of a quality certificate and paradata with the Digital Twin. This provides a transparent record of how the geometry was acquired, processed and validated, allowing researchers in different countries and institutions to understand and assess the reliability of the digital representation. In this sense, a Digital Twin can function almost as a digital passport for a heritage asset, carrying its technical identity, provenance and quality information as it moves across research infrastructures.

At European level, I see strong

potential for integration with ecosystems such as Europeana, EOSC, DARIAH-ERIC, CLARIN-ERIC and emerging European data-space initiatives, as well as with specialised Digital Heritage infrastructures and projects such as EUReka3D and EUReka3D-XR. The objective should not be to create another isolated heritage platform, but to enable a federated ecosystem in which institutions retain stewardship of their data while Digital Twins remain discoverable, identifiable and interoperable across borders.

At global level, the potential is even greater. Digital Twins created in Cyprus could be connected with corresponding heritage assets in Europe, the Mediterranean and beyond, enabling comparative research, cross-border documentation, conservation and education. Here, the Memory Twin provides an additional layer: while the Digital Twin remains the geometrical representation, the Memory Twin connects Digital Twins through semantic knowledge, provenance, historical context, narratives and human values.

Ultimately, the long-term vision is not a single global repository containing all cultural heritage data. It is a federated network of interoperable Digital Twins, connected through common standards, persistent identities, FAIR and CARE principles, quality certification and shared knowledge structures. Such an ecosystem could transform Digital Cultural Heritage from a collection of isolated digital models into a genuinely connected global research infrastructure.

The real opportunity is therefore not to build one Digital Twin of the world's heritage, but to create the interoperability that allows millions of Digital Twins to communicate, be trusted, and contribute collectively to our understanding and preservation of the world's cultural memory.