Treddì: a Semantic Digital Library for 3D cultural heritage

Valentina Bertelli, Giorgia Umana

Purpose

Treddì is a semantic digital library that aims to collect, organize and make accessible 3D models of international cultural heritage, allowing their dissemination and free reuse.

3D models are a fundamental tool for the preservation, research and analysis of cultural heritage, enabling the documentation of monuments, finds and archaeological sites with a high level of detail and offering new opportunities for study and dissemination.

Creating them requires time, technical skills and resources, and often, once used for specific research projects, they end up being forgotten. Our aim is to centralize and collect these models within a single portal, allowing scholars, professionals and enthusiasts to access, consult and reuse them.

To ensure effective cataloging and facilitate research, the project is based on appropriate metadata and ontologies, which allows each model to be accurately described based on criteria such as technical characteristics.

State of the art

Twin it! 3D - Europeana
[Twin it! 3D](#) is a campaign conducted by the *European Commission* and the *Europeana Initiative* that collects 3D models of buildings, sites and objects in Europe. Contents are described following the Europeana Data Model ontology, which currently lacks the necessary terminology to accurately describe the technical characteristics of 3D models, although further extensions are still in development.

The OpenHeritage3D Project
Run by the *Cultural Heritage Engineering Initiative* (CHEI) at Qualcomm Institute, **[OpenHeritage3D](#)** is an initiative that provides free access to raw 3D data such as, LiDAR - Terrestrial, LiDAR - Aerial, Photogrammetry - Terrestrial, Photogrammetry - Aerial and Short Range Scans, and the related metadata of cultural heritage sites across the world. It's a joint project between *CyArk*, *Historic Environment Scotland* and the University of South Florida Libraries. Due to its highly specialized nature, the platform is primarily intended for a professional audience rather than the general public.

Open Heritage

[Open Heritage](#) is part of the *Google Arts & Culture* initiative created in collaboration with *CyArk* and The *Digital Heritage & Humanities Collection*s (DHHC) with the University of South Florida (USF) Libraries. The main aim of the initiative is to preserve and share the world's art and culture to the general public, in collaboration with more than 2000 institutions across the globe, however few items are properly described with extensive metadata.

Having analysed the characteristics and qualities of these three initiatives we considered how our project could differentiate itself from them. Our strength lies in the creation of an international platform dedicated solely to 3D models of the cultural heritage domain, making them accessible to researchers, professionals and enthusiasts around the world. The use of appropriate metadata and ontologies ensures structured descriptions of the models facilitating their reuse and promoting greater collaboration between scholars and institutions. Technical details, such as data acquisition methods and the processes involved in model creation, significantly impact the quality and reliability of the models. However, we observed a lack of adequate mechanisms to fully describe these aspects. To address these limitations, we focused on identifying suitable approaches to represent the activities and techniques involved in 3D model creation, using established ontologies in the cultural heritage domain, such as Dublin Core and CIDOC CRM.

Gather Digital Resources

Treddì aims to gather high-quality 3D models related to cultural heritage. Ideally, models will be provided by cultural institutions, such as research centers, museums, or archives, from around the world, that create models for research purposes and wish to make them available to the public once they have completed their studies, allowing others to discover and reuse them. In addition to the models themselves, partner institutions are required to provide a set of information regarding both the 3D model and its physical counterpart that will be included in the metadata.

The actual uploading and integration of the materials into the platform would be carried out by the project team. Because the project is being developed as a student initiative it does not include active institutional partners: all materials used have been sourced from the open platform Sketchfab, serving as placeholders.

Licensing and Copyright

Treddì is designed as an open platform where content can be accessed, visualized, and shared. Users will be able to download and reuse models for research purposes or simply for enjoyment. For this reason models will be available under a [CC BY-NC-SA](#) license, allowing users to share and adapt content for non-commercial purposes, with appropriate credit given to the creators, mentions of eventual changes made to the model and without the possibility of changing the license.
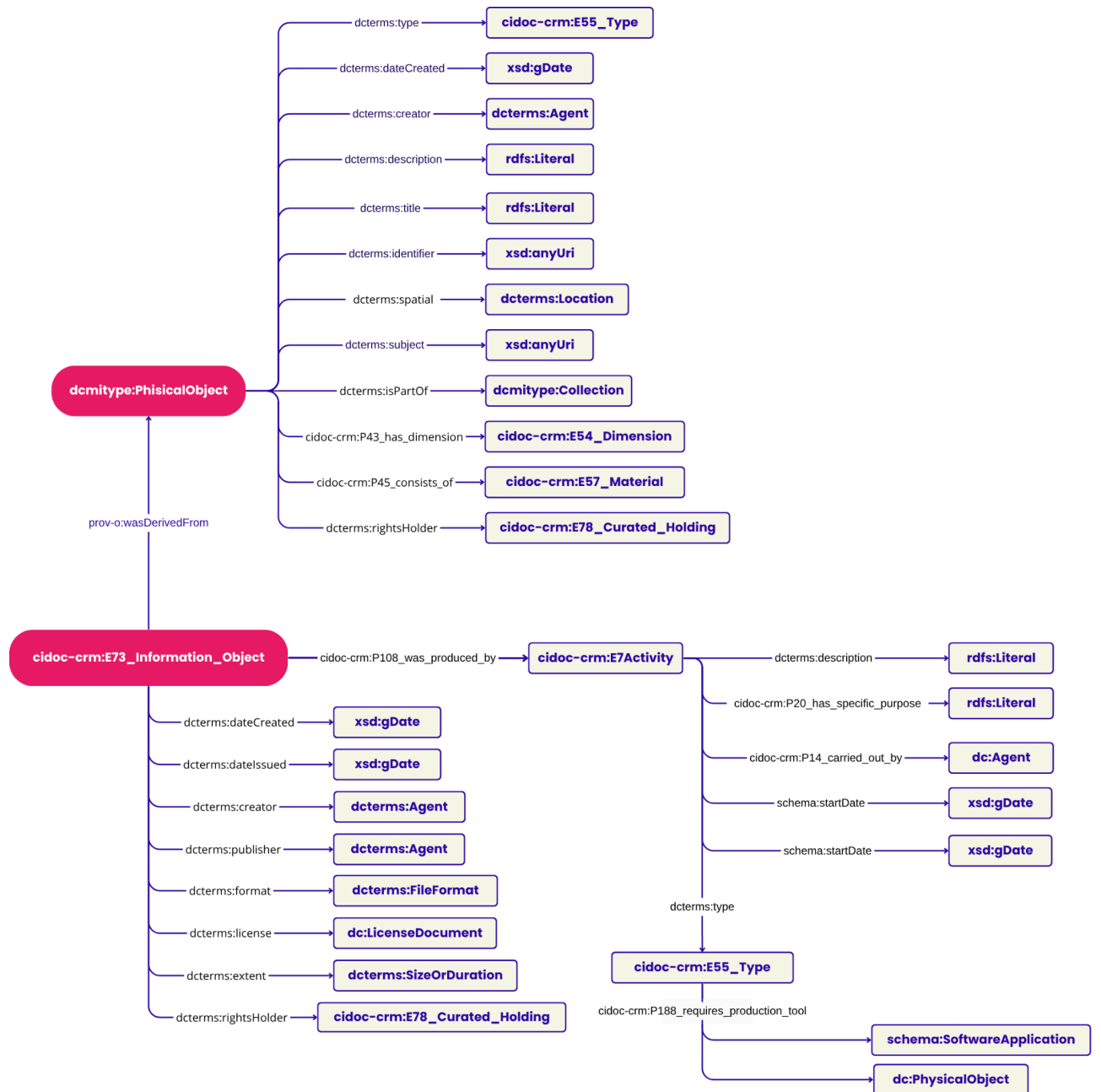
Treddì Ontology

3D models are digital representations that require specific descriptors through metadata to facilitate the process of identification, interpretation, interoperability and reuse.

The hardware and software used to create 3D models significantly influence the models themselves. Therefore, having a structure to describe this information is essential for properly identifying models and distinguishing between different digital representations of the same real-world object.

3D models of cultural heritage are digital representations of real-world objects and should be described as such, not as the objects themselves. When designing a schema to describe 3D models, it's crucial to consider how to treat them as independent entities while also preserving their connection to the original object and its cultural context.

Users should have access to information related to data collection, image acquisition, production, and post-production processes. This technical information is vital for assessing the degree of metric and chromatic fidelity to the real-world object, helping to determine whether a model faithfully represents the original. This is the ultimate goal in the creation of 3D models related to cultural heritage.

Our ontology is available in turtle format at this link.

Treddì Ontology

System Architecture

Treddì is built on Omeka S, to ensure scalability, accessibility, and long-term sustainability for 3D digital cultural heritage preservation.

To host the Omeka S installation and make it publicly accessible, a virtual machine has been deployed using Google Cloud Platform (GCP). This allowed us to install a Linux server, set up the necessary web environment, and make our digital archive available to external users.

Omeka S serves as the foundation of the backend: role based access control is supported (Admin, Contributor or Public Viewer) and structured metadata is stored in MySQL, using Dublin Core, CIDOC CRM, and IIIF standards for interoperability. Omeka's file management system is used for file uploads, versioning, and metadata linking.

Treddì exploits Omeka S search functionalities. Omeka's browsing page offers users a wide range of filters to explore the collection and retrieve contents. Filters allow to search items with a certain class or with specific values associated with properties.

Information organization

The main building block of the Omeka S system are the **Items**. They can be used as nodes to represent entities that can be described with metadata and linked to each other to display meaningful relationships. Items can have **Media** attached: they can be created by adding them to an item and cannot exist independently.

We decided to exploit this structure to represent the complex relationship between 3D models and their physical counterpart. Original artifacts are considered as Items, while their virtual representations are linked to them as Media. This solution assures a direct connection between object and model while at the same time allowing separate metadata descriptions, according to their specificity.

Since for the sake of this project 3D models were selected from sketchfab, metadata may lack some information because they are missing from the original resource. In an ideal scenario, this problem would be avoided by having institutions sending both content and metadata directly to Treddì.
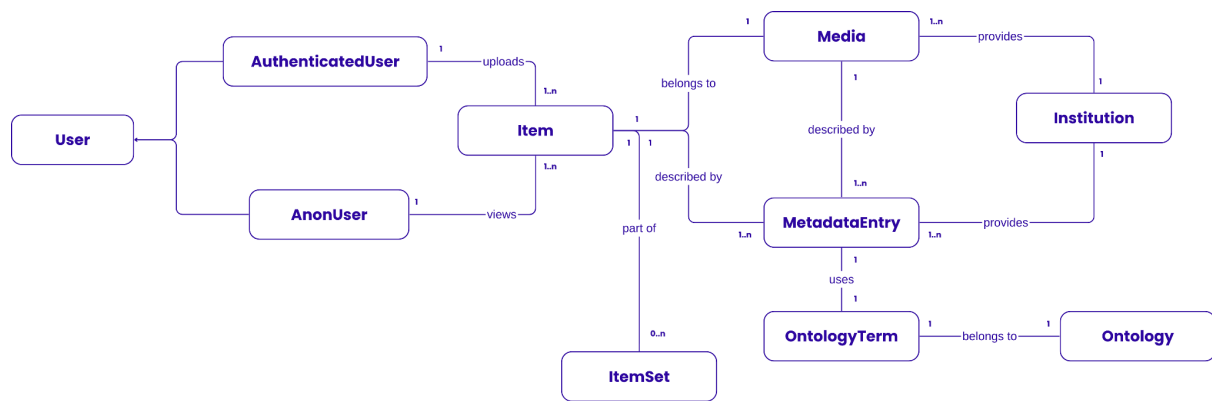
Entity relationship model

Controlled vocabularies and external links

Controlled vocabulary were used to enhance knowledge organization and semantic interoperability:

- The Getty Art & Architecture Thesaurus was used to describe types and subjects of Items and Media.
- Getty's Union List of Artist Names provided standardized references for the authors of physical objects.
- GeoNames was used to identify places and institutions.
- Additionally, links to Sketchfab pages were included to reference the selected 3D models and their creators.

3D models visualization

Omeka S theme Lively was used to style Treddì's website. HTML and CSS were then customized for a user-friendly experience. In particular, item's pages were modified to handle real-time web-based 3D visualization by integrating the <model-viewer> web component. Users can interact with the models directly, without having to open a new page managed by third parties. The models that have been uploaded to Treddì are all in glb format because it is one of the most common and lighter formats for 3D models, both for the systems (and for our computers).

Output list

- Omeka S based semantic digital library
- An ontology to describe 3D models and related metadata
- Documentation related to the development of the platform

Bibliography

Guidi, Gabriele & Frischer, Bernard. (2020). 3D Digitization of Cultural Heritage. 10.1007/978-3-030-44070-1_13.

Isaac, Antoine. (2024) Review of EDM to support 3D. https://pro.europeana.eu/post/review-of-the-europeana-data-model-to-support-3d

Koller, David & Frischer, Bernard & Humphreys, Greg. (2009). Research challenges for digital archives of 3D cultural heritage models. JOCCH. 2. 7. 10.1145/1658346.1658347.

Niccolucci, Franco; D'Andrea, Andrea. "An ontology for 3D cultural objects". Proceedings of the 7th International conference on Virtual Reality, Archaeology and Intelligent Cultural Heritage (VAST'06). 2006. Eurographics Association, Goslar, DEU, 203–210.

Polo, María-Eugenia; Durán-Domínguez, Guadalupe; Felicísimo, Ángel M. . "Proposal of metadata schema for capturing and processing 3D models in an archaeological context", Digital Applications in Archaeology and Cultural Heritage, vol. 34, 2024, https://doi.org/10.1016/j.daach.2024.e00347.

Razdan, Anshuman & Rowe, Jeremy & Tocheri, Matt & Sweitzer, Wilson. (2002). "Adding Semantics to 3D Digital Libraries". 419-420. 10.1007/3-540-36227-4_47.

Sitography

Art & Architecture Thesaurus (Getty Research Institute). (n.d.). Getty Museum. Retrieved June 4, 2025, from https://www.getty.edu/research/tools/vocabularies/aat/index.html

(n.d.). CIDOC CRM: Home. Retrieved June 1, 2025, from https://cidoc-crm.org/

(n.d.). DCMI: Home. Retrieved June 1, 2025, from https://www.dublincore.org/

(n.d.). GeoNames. Retrieved June 1, 2025, from https://www.geonames.org/

Getty Union List of Artist Names (Research at the Getty). (n.d.). Getty Museum. Retrieved June 1, 2025, from https://www.getty.edu/research/tools/vocabularies/ulan/index.html

Model Viewer. (n.d.). <model-viewer>. Retrieved June 1, 2025, from https://modelviewer.dev/

Omeka S. (n.d.). Omeka. Retrieved June 1, 2025, from https://omeka.org/s/

(n.d.). Omeka S Lively theme. https://omeka.org/s/themes/lively/

PROV-O: The PROV Ontology. (2013, April 30). W3C. Retrieved June 1, 2025, from https://www.w3.org/TR/prov-o/

(n.d.). Schema.org - Schema.org. Retrieved June 1, 2025, from https://schema.org/

Download Free 3D Models - Royalty Free. (n.d.). Sketchfab. Retrieved June 1, 2025, from https://sketchfab.com/features/free-3d-models

Byrd, N. (n.d.). *How To Create A Digital Library Share Tweet*. Byrdnick. https://byrdnick.com/archives/6356/how-to-create-a-digital-library#google_vignette

Oguche, D. (n.d.). *Standards and Protocols for Implementing Digital Libraries*. IntechOpen. Retrieved May 14, 2025, from https://www.intechopen.com/chapters/1143945