COLOURS TOOL · PERCEIVE LEGACY

Multi-Layer eXtensible eXplorer (MuLaX)

Interactive exploration of multi-layered 3D cultural heritage collections.

Web3D / WebXR Cultural Heritage | Multi-Layer Diagnostic Visualization | Interactive Semantic Annotation | Digital Twin Inspection | Immersive Heritage Exploration

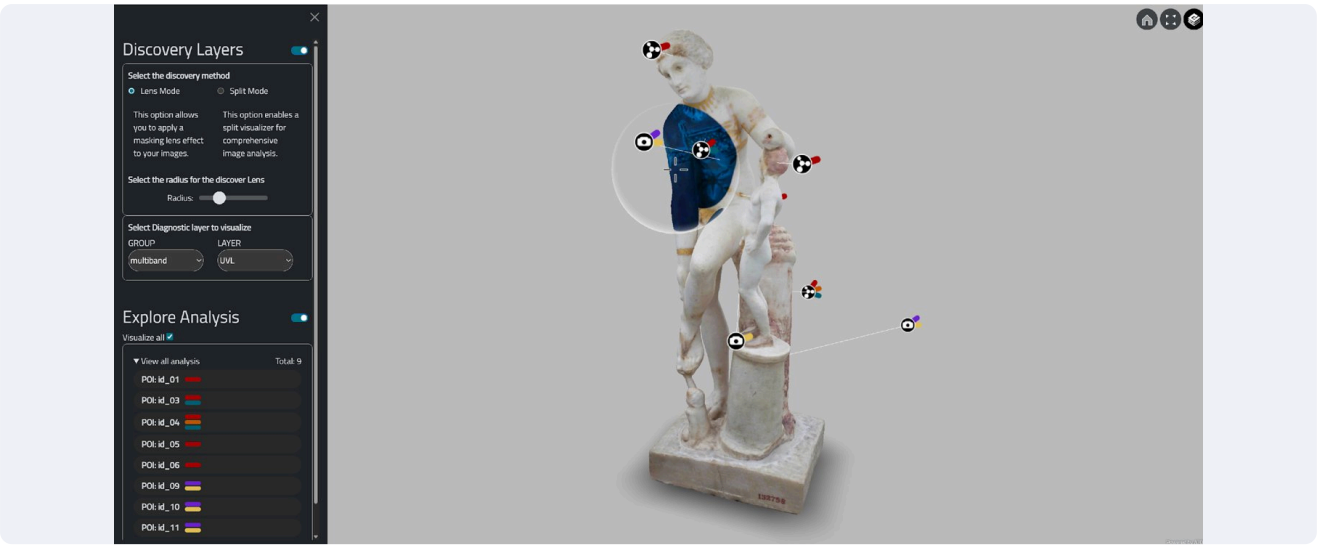


Fig. 1: Main dashboard of the MuLaX tool.

OVERVIEW

MuLaX is an interactive Web3D/WebXR tool designed and developed under the PERCEIVE European project. It enables the online exploration of multi-layered 3D cultural heritage collections enriched with diagnostic and analytical data. Built on the open-source ATON framework developed by CNR ISPC, MuLaX integrates high-resolution 3D models with multi-band imaging datasets (e.g., VIS, UVL, VIL) and punctual analyses (e.g., XRF, microscope, FORS), allowing users to visually compare and inspect heterogeneous scientific results within a single environment.The tool supports advanced multi-layer discovery techniques, such as lens and split modes, semantic annotations, texture-based masks, and interactive semantic painting. It is accessible directly via web browser on any device, from smartphones to immersive XR headsets, ensuring wide interoperability and remote collaboration.

By integrating analytical datasets into spatially referenced 3D environments, MuLaX facilitates documentation, monitoring, interpretation, and communication of diagnostic processes for both experts and broader audiences.

KEY FEATURES

- Interactive multi-layer discovery (lens and split modes) for analytical imaging (UVL, VIL, VIS)
- Integration of punctual analyses (XRF, microscope, FORS) as spatially referenced POIs
- Texture-based semantic masks and dynamic image-based masking
- Interactive Semantic Painting (ISP) to create expert-driven masks directly online
- Cloud integration for remote access to collections and analytical layers
- Responsive Web3D interface compatible with desktop and mobile devices
- WebXR immersive inspection in VR and AR modes
- Modular architecture supporting extension to paintings, textiles, and other domains.

IN PRACTICE: A USER STORY

Luca is a conservation scientist studying residual polychromy on a Roman statue.

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The statue has undergone multiband imaging campaigns, including VIS, UVL, and VIL acquisitions, along with XRF spot analyses.

Instead of navigating separate datasets, Luca opens MuLaX directly in his web browser. The digital twin of the statue loads instantly from the cloud collection. He activates the Discovery Layers tool and selects UVL. Using the lens mode, he moves a circular inspection area across the sculpture's surface, revealing luminescent traces invisible under normal light. Switching to split mode, he compares visible and hidden layers side by side, sliding along the Y-axis for direct visual contrast. Curious about a gilded detail, Luca selects a Point of Interest (POI) marked with a spot-analysis icon. A side panel opens, displaying XRF spectra and microscope images linked to that precise location. He zooms into the graph to confirm pigment composition.

Later, wearing a VR headset, Luca enters immersive inspection mode via WebXR. The interface appears anchored to his wrist, allowing him to toggle layers while walking around the virtual statue

Meanwhile, a colleague remotely adds a semantic mask to highlight areas of suspected Egyptian blue. The update appears instantly in Luca's session, demonstrating real-time collaborative workflows.

MuLaX transforms fragmented scientific datasets into a unified, spatially coherent experience, supporting analysis, interpretation, and communication.

WHY ON THE CULTURAL HERITAGE CLOUD?

MuLaX was conceived within the PERCEIVE cloud ecosystem and already integrates centralized collections and remote processing services. Deploying MuLaX on the ECCCH is a natural technical evolution. ECCCH provides structured storage for 3D assets, analytical layers, semantic masks, and metadata, ensuring interoperability and long-term preservation. MuLaX can retrieve and visualize these resources dynamically while allowing other services (e.g., AI-based segmentation or predictive models) to generate new layers directly in the cloud data layer.

This architecture supports distributed collaboration, version control, and secure authentication – core features for interdisciplinary heritage science. Cloud integration guarantees scalability, cross-institutional access, and alignment with European standards for digital heritage infrastructures.

WHO CAN USE IT

MuLaX serves conservation scientists, archaeologists, art historians, and diagnostic laboratories working with multi-band imaging and material analyses. Museum professionals benefit from integrated visualization for exhibition design and public communication. Researchers studying ancient polychromy, restoration history, and material degradation can use MuLaX to compare heterogeneous datasets within a unified spatial framework. XR capabilities also support education, outreach, and immersive museum experiences.

Within a cloud-based European infrastructure, additional users may include research infrastructures, universities, heritage agencies, digital humanities scholars, and SMEs developing analytical or visualization services. Its modular architecture allows extension beyond statuary to paintings, textiles, and works on paper broadening its impact across heritage domains.

EXPECTED TIMELINE

Prototype Done
Validated in PERCEIVE

Beta Ongoing
User feedback, support for paintings

Release ECCCH
Cloud-native, stable release

MuLaX was originally developed under the PERCEIVE project and has reached a functional, publicly demonstrated prototype stage. An Alpha version was achieved during PERCEIVE, validating core functionalities such as multi-layer discovery, semantic masks, and WebXR inspection. A Beta iteration is currently evolving, incorporating user feedback, UI refinements, and extended support for other artworks like paintings. Future integration within ECCCH infrastructure would enable full cloud-native deployment, interoperable APIs, and stable production release aligned with subsequent European initiatives.

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MORE IMAGES



Fig. 2–4: Diagnostic data visualisation with PERCEIVE MuLaX on desktop, AR and VR.

CONTACT

Bruno Fanini, CNR ISPC · bruno.fanini@cnr.it

All COLOURS tools:
colours-eccch.eu/tools

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