From 3D documentation to XR representation of Cultural Heritage buildings – The case of the Katholikon of St. Stephen, Meteora

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Presentation Outline

Objectives & The Case Study

Data Collection & 3D Modelling

The XR Platform

Contribution & Future Work
Objectives

Multi-representation of the restoration phases of a Byzantine church

Low-cost photogrammetric methodology for the 3D documentation of complex historic buildings.
- recording, analysis and monitoring of temporal changes
- facilitation of maintenance planning, interpretation and collaboration

Web-based XR platform for the visualization, dissemination & integration of the produced data.
- eXtented Reality (XR): Virtual Reality (VR) & Augmented Reality (AR)
- various visualization modes, interaction tools and multimedia
16th century old church (Katholikon) of St. Stephen’s Monastery in the UNESCO site of Meteora, Greece

- small, low, timber-roofed, single-naved basilica with narthex.
- southern side carved into a rock
16th century old church (Katholikon) of St. Stephen’s Monastery in the UNESCO site of Meteora, Greece

- frescoes of 1545, post-Byzantine period including the “24 Oikoi” of the Theotokos & depictions of full-body saints
Restoration Work

- cleaning & conservation of frescoes & murals, replacement of carving, piercing into existing stonework, repointing & reproduction of original mouldings

16th century old church (Katholikon) of St. Stephen’s Monastery in the UNESCO site of Meteora, Greece
Data Collection


- Outdoor: UAV flight (≈ 1450 vertical & oblique images)
- Indoor: Close-range photogrammetry (≈ 4500 images in total)
- Terrestrial measurements

- Canon EOS 6D camera, 24 mm
- 6.7 μm pixel size & 5472 x 3648 pixels resolution
- 43 GPCs – Total Station equipment
Image-based 3D modeling - Computer Vision algorithms

- Images orientation through SfM & DIM
- Dense point clouds
- 3D surface through Multi-view Stereo
- Separation of the mesh to sub-meshes for high-resolution texture mapping

**Agisoft Metashape & Geomagic Wrap Studio software**

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<th>2nd instance</th>
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<tr>
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<td>Tie points (image)</td>
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Results of 3D Documentation

3D Textured Models

<table>
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<tr>
<th>Initial State</th>
<th>Current State</th>
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<tr>
<td>Size</td>
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Northern section of St. Stephen’s church

before & after the restoration works
Orthoimages

Initial State

Current State
Orthoimages

*Initial State*

*Current State*
XR Platform

Three session modes with scalable levels of immersion

- WebGL 3D Visualization
- Virtual Reality (VR) by WebXR
- Web Augmented Reality (WebAR)

Front-end Technologies

- Nexus.js library
- Three.js library

Adaptive rendering & progressive loading by multi-resolution format

Open-source 3D graphics library providing a scene-graph scheme & an imperative API for the construction of 3D scenes

(HTML, CSS & JavaScript) | Bootstrap framework | jQuery library
XR Platform

Three session modes with scalable levels of immersion

WebGL 3D Visualization

Tween.js library:
- camera’s position, field of view & aspect ratio for a smooth motion through a specific path in the 3D scene
  `<Quadratic.In>` interpolation

Virtual Reality (VR) by WebXR

WebXR API:
- web content with Mixed Reality hardware
- compatible with a WebXR browser or 6DOF headsets
- `<renderer.xr>` enabled by WebGL renderer of Three.js

Web Augmented Reality (WebAR)

AR.js & Handtrack.js libraries:
- marker-less AR based on hands tracking & recognition
- superimposition via the camera of a handheld device
- CNN hand detection model for location hands prediction
Tools of XR Platform

4D Viewer | Basic Visualization mode
Self-Guided Virtual Tour

- Simulation of the user’s vision for a natural perspective of walking around the church
- First-person camera & control with arrow keys
- 3D arrow for orientation
- Clickable highlighted geometry as an annotation tool for points of interest

Annotations and Information retrieval

- Information about the architectural features, the structure and the state of conservation
- Photographic & conservation documentation
Automatic Virtual Tour

- The camera path of the automatic navigation tour through the various sections of the church
- Brief descriptions in the form of subtitles imitating a narrative storytelling
- Sequential seamless animations of the camera
Web VR free exploration

- Specialized VR/XR gear or WebXR emulation plugin
- Compatibility check at runtime
- Camera crosshair for orientation to the camera’s point of focus
- The floors and walls are outlined
Web AR exploration

- Pattern-based paradigm with hand detection model & robust tracking mode against occlusion
- Camera permission required
- 3D lines indicate the hand detection & tracking
- Instructions – guidelines for the user
- Palm facing up as an attachment point where the 3D model is superimposed at a given pose
Contribution & Conclusions

3D Modeling Workflow

- Documentation of maintenance and repair inspections carried out at regular intervals
- Digital conservation, sustainability
- Collaboration of multiple disciplines, dissemination
Contribution & Conclusions

3D Modeling Workflow

- Documentation of maintenance and repair inspections carried out at regular intervals
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Future Work

- Integration of more features of WebXR
- Implementation without the need of dedicated XR devices
- Extensibility: Database management system, annotations, semantic segmentation - classification etc.

XR Platform

- Interactive visualization of spatial and temporal restoration changes, remote-access, content updating
- Knowledge sharing, simulation of on-site experience

Researchers, scientists and professionals of the Cultural Heritage field

Simple users and potential visitors of the Cultural Heritage site

3D Modeling Workflow

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