SMART SURVEYORS FOR LAND AND WATER MANAGEMENT
CHALLENGES IN A NEW REALITY
e WORKING WEEK 2021

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

Paper id: 11027

Charalabos Ioannidis, Sofia Soile, Argyro-Maria Boutsi*, Styliani Verykokou, Fotis Bourexis and Chryssy Potsiou

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

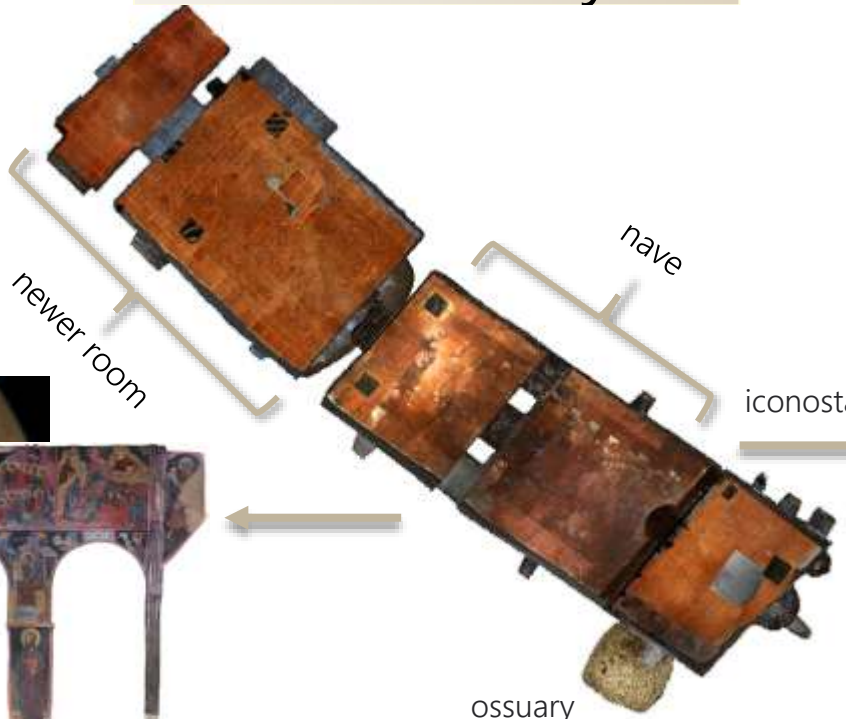
Case Study

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

Case Study

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

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

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

Data Collection

Data capturing before (2018) & after (2019) maintenance works & interventions

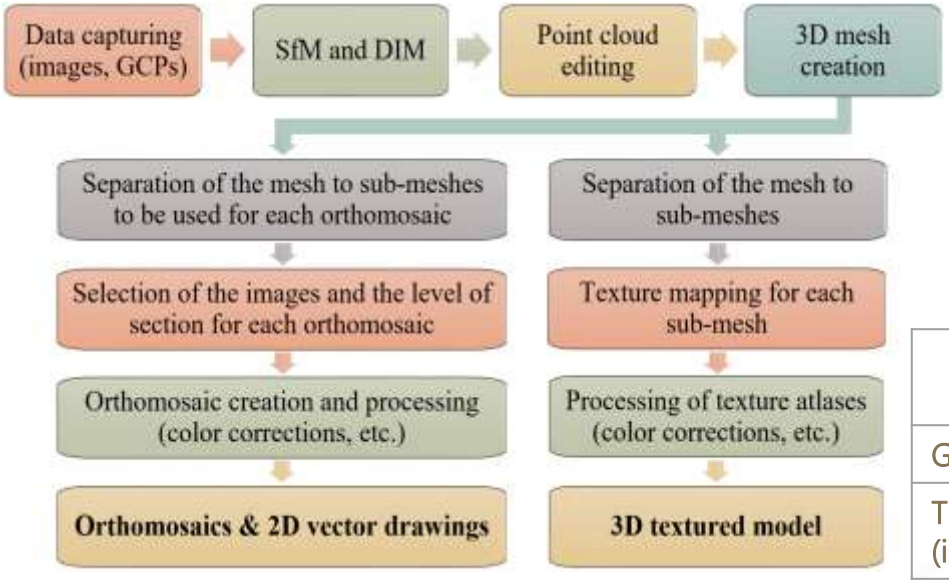
- Outdoor: UAV flight (≈ 1450 vertical & oblique images)
- Indoor: Close-range photogrammetry (≈ 4500 images in total)
- Terrestrial measurements

- Canon EOS 6D camera, 24 mm
- 6,7 µm pixel size & 5472 x 3648 pixels resolution
- 43 GPCs – Total Station equipment

Data Processing

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



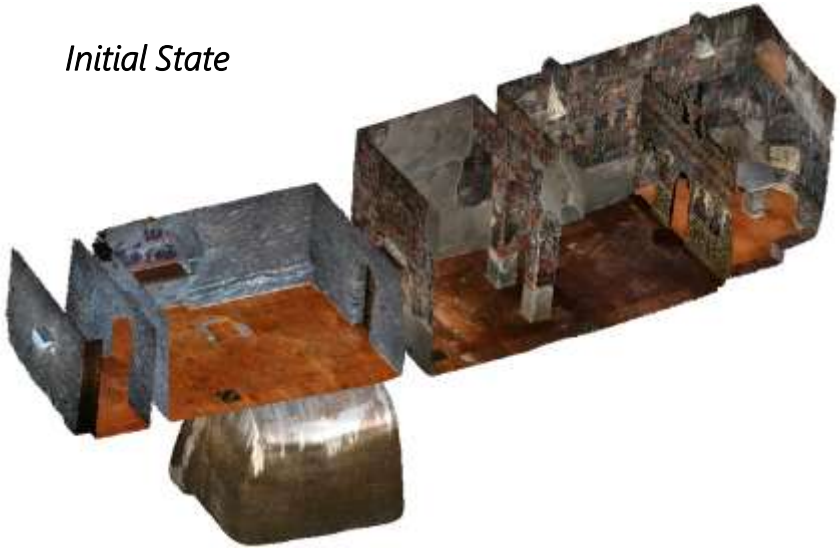
- Agisoft Metashape & Geomagic Wrap Studio software

	1st instance	2nd instance
GCPs	4.5 mm	5 mm
Tie points (image)	1.6 pixels	1.3 pixels

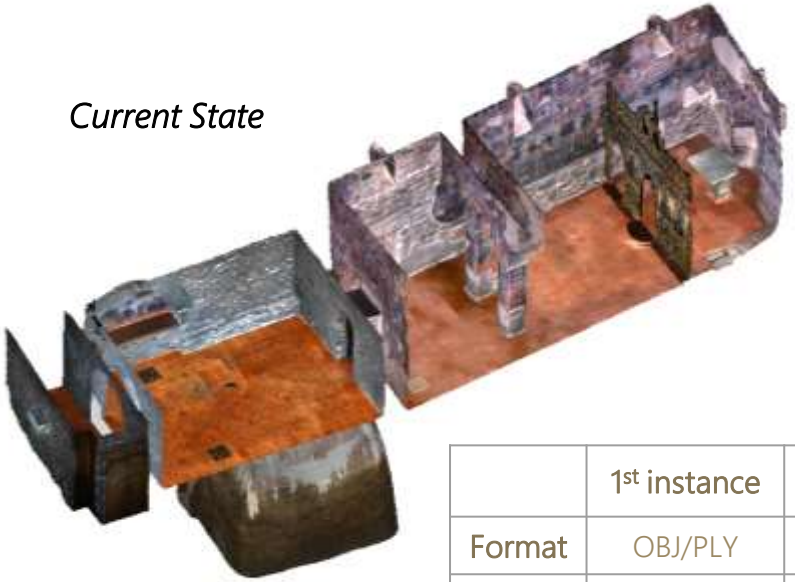
Results of 3D Documentation

3D Textured Models

Initial State



Current State



	1st instance	2nd instance
Format	OBJ/PLY	OBJ/PLY
Size	765/537 MB	840/600 MB

Orthoimages

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)

- Nexus.js library
- Three.js library
- Front-end Technologies

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

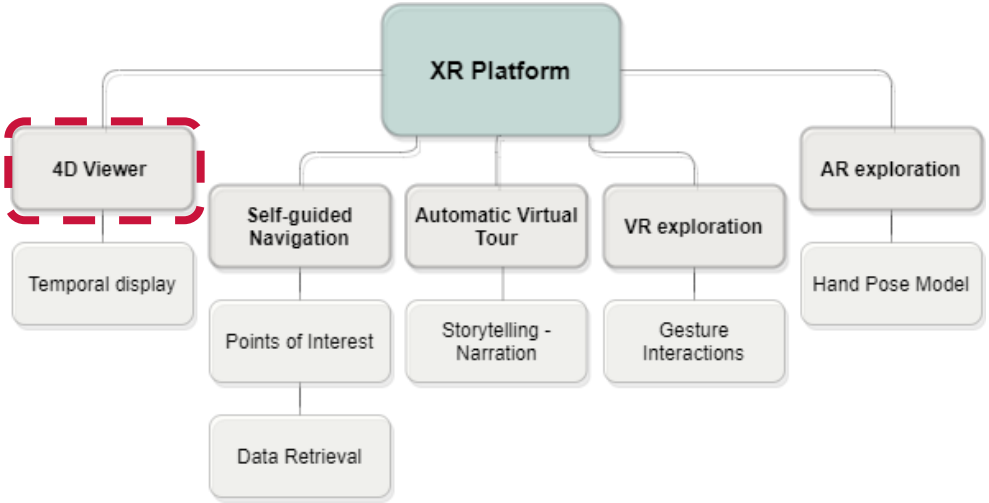
Web Augmented Reality (WebAR)

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

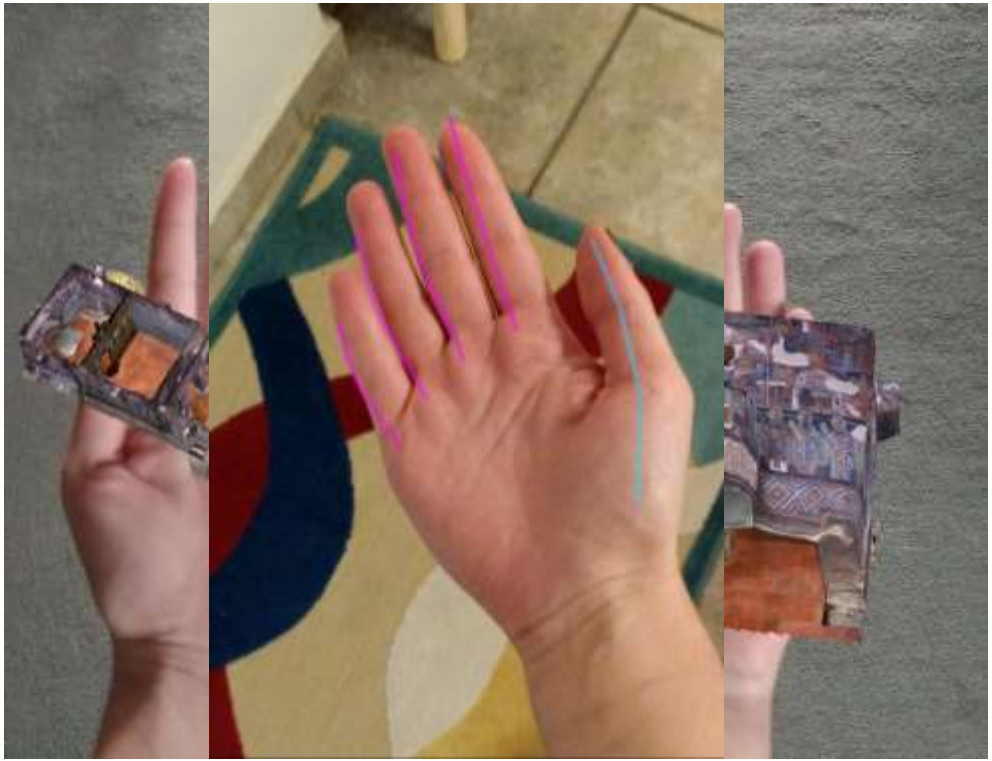
- The camera path of the automatic navigation tour through the various sections of the church
- Brief descriptions in the form of subtitles imitating a narrative storytelling
- Sequential seamless animations of the camera

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

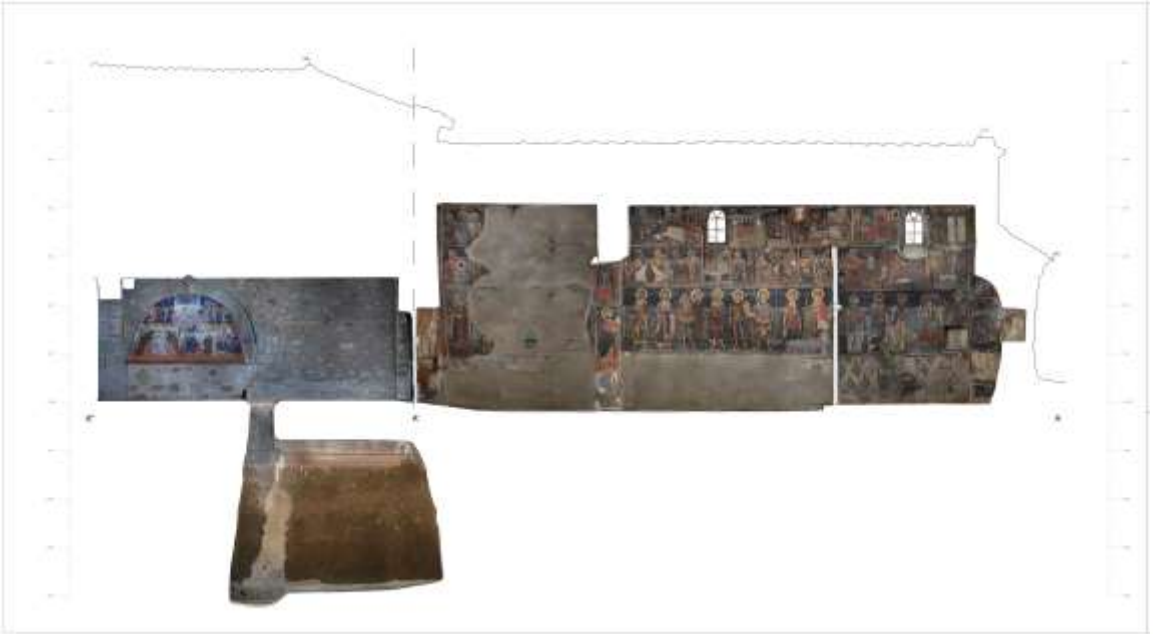
- Pattern-based paradigm with hand detection model & robust tracking mode against occlusion
- Camera permission required
- 3D lines indicate the hand detection & tracking
- Instructions – guidelines for the user
- Palm facing up as an attachment point where the 3D model is superimposed at a gived pose



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
- Digital conservation, sustainability
- Collaboration of multiple disciplines, dissemination

XR Platform

- Interactive visualization of spatial and temporal restoration changes, remote-access, content updating

→ Researchers, scientists and professionals of the Cultural Heritage field

- Knowledge sharing, simulation of on-site experience

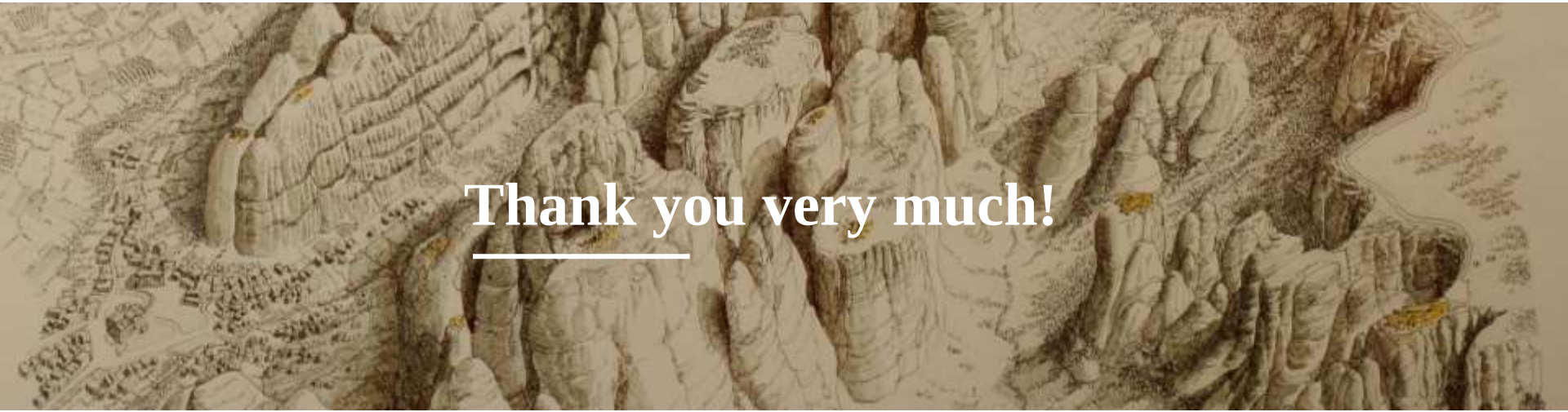
→ Simple users and potential visitors of the Cultural Heritage site

Future Work

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

FIG NL THE NETHERLANDS
e WORKING WEEK 2021

SMART SURVEYORS FOR LAND AND WATER MANAGEMENT
CHALLENGES IN A NEW REALITY



Thank you very much!

Acknowledgements:

This research has been co-financed by the European Union and Greek national funds through the Operational Program "Competitiveness, Entrepreneurship and Innovation", under the call RESEARCH–CREATE–INNOVATE (project code: T1EDK02859).

Ευρωπαϊκή Ένωση
ΕΠΑνΕΚ 2014-2020 ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΑΝΤΑΓΩΝΙΣΤΙΚΟΤΗΤΑ ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ ΚΑΙΝΟΤΟΜΙΑ
ΕΣΠΑ 2014-2020
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης