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

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

ORGANISED BY FIG
PLATINUM SPONSORS Trimble. esri THE SCIENCE OF WHERE
ΕΠΑνΕΚ 2014-2020 ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΑΝΤΑΓΩΝΙΣΤΙΚΟΤΗΤΑ ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ ΚΑΙΝΟΤΟΜΙΑ
ΕΣΠΑ 2014-2020
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

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

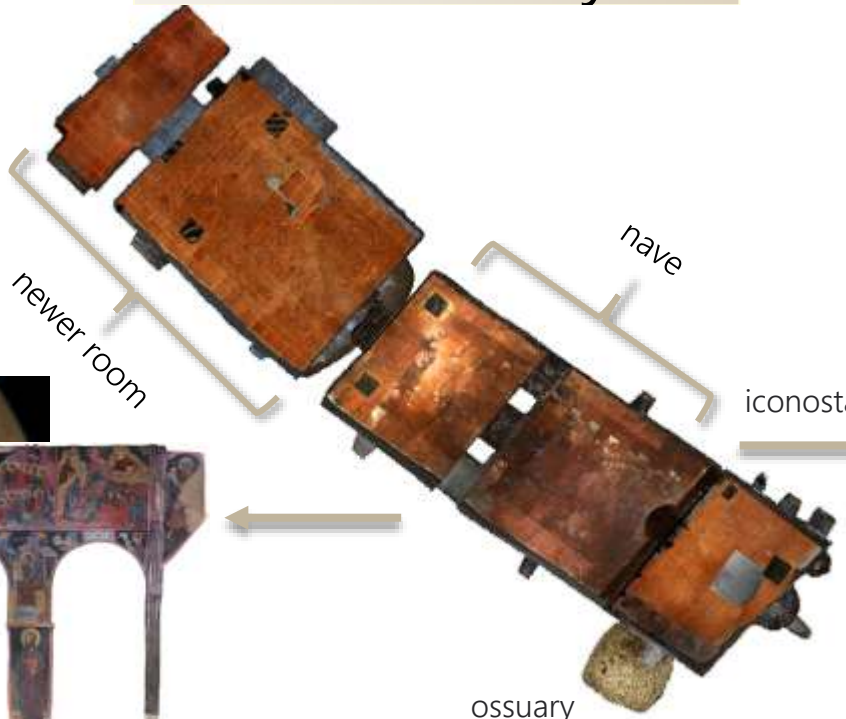
Case Study

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

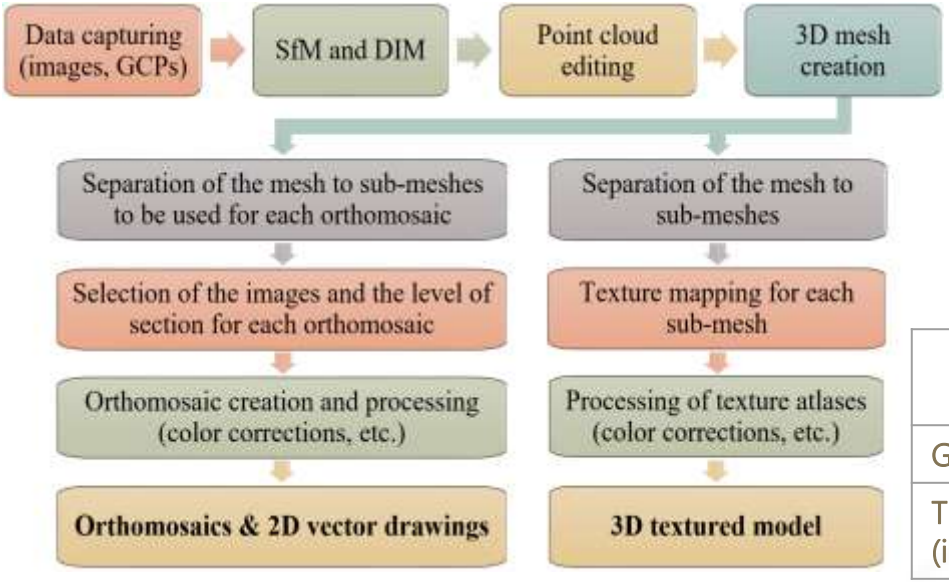
- Outdoor: UAV flight (≈ 1450 vertical & oblique images)
- Indoor: Close-range photogrammetry (≈ 4500 images in total)
- Terrestrial measurements

- 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



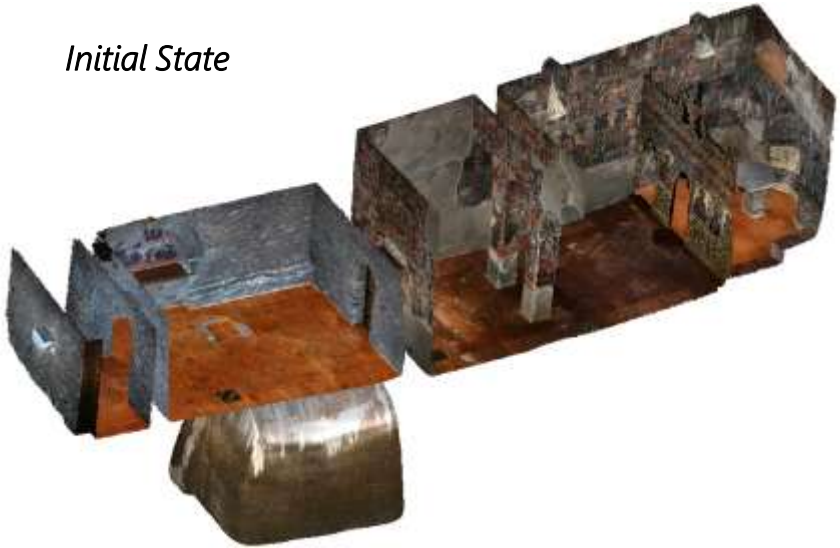
- Agisoft Metashape & Geomagic Wrap Studio software

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

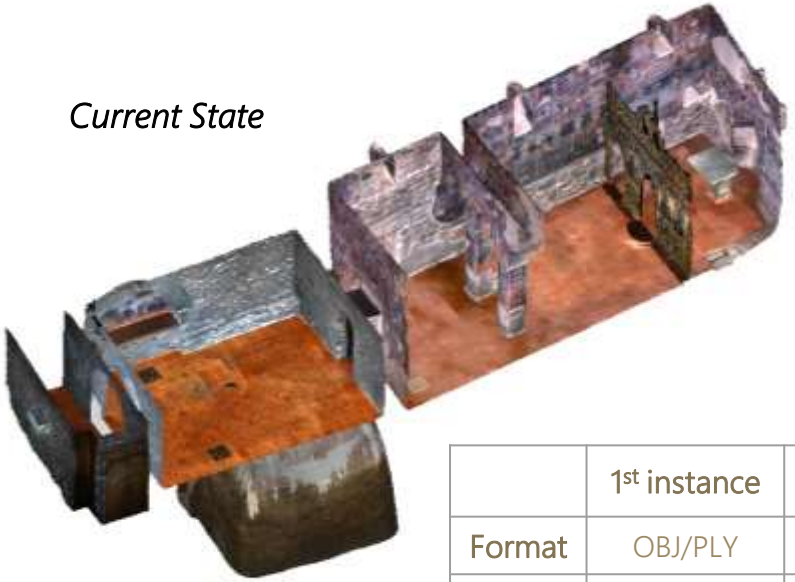
Results of 3D Documentation

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

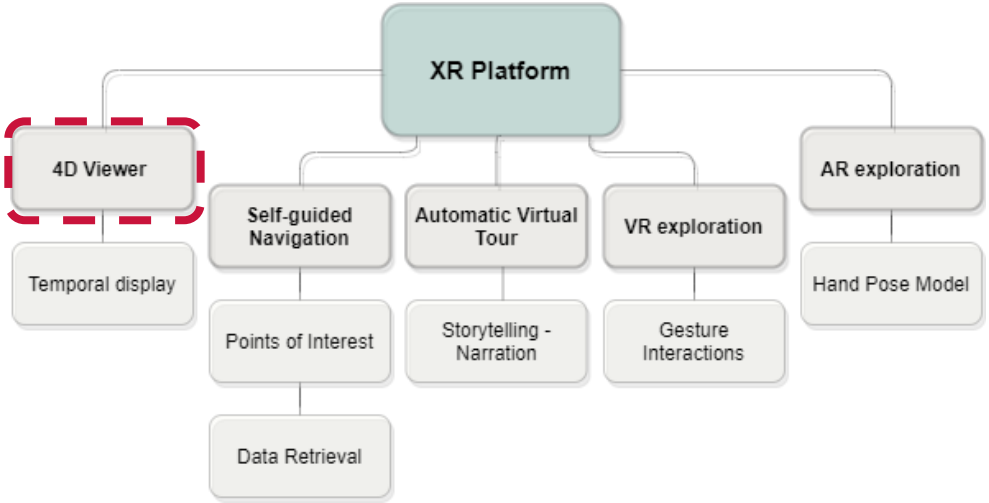
Web Augmented Reality (WebAR)

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

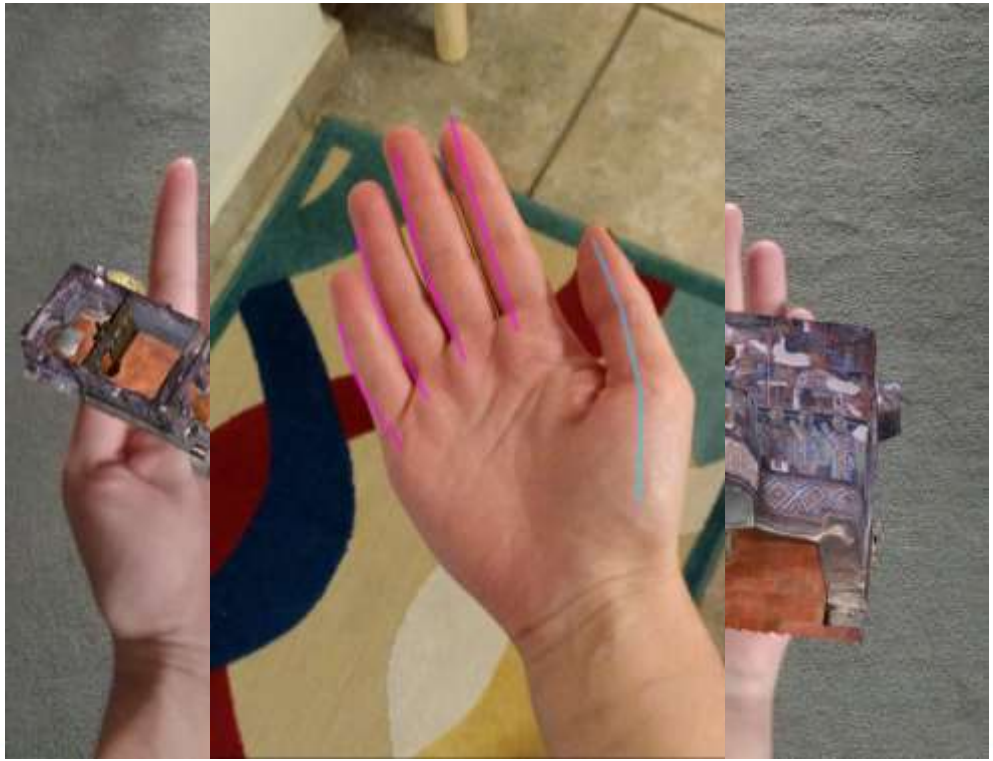
- The camera path of the automatic navigation tour through the various sections of the church
- Brief descriptions in the form of subtitles imitating a narrative storytelling
- Sequential seamless animations of the camera

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

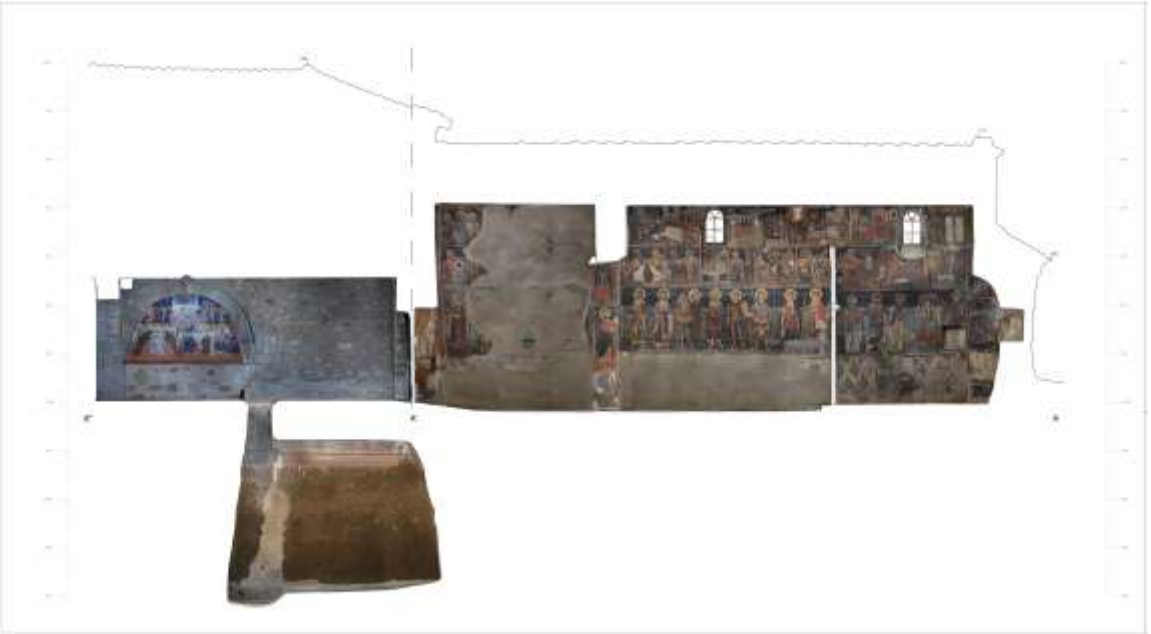
- Pattern-based paradigm with hand detection model & robust tracking mode against occlusion
- Camera permission required
- 3D lines indicate the hand detection & tracking
- Instructions – guidelines for the user
- Palm facing up as an attachment point where the 3D model is superimposed at a gived pose



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

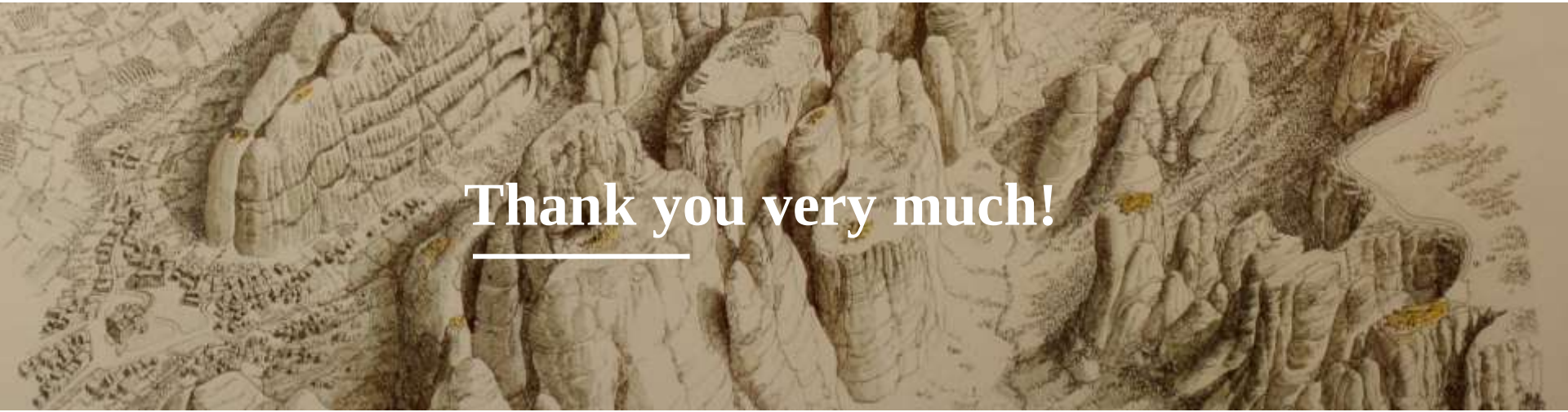
→ Simple users and potential visitors of the Cultural Heritage site

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