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

Charalabos IOANNIDIS, Sofia SOILE, Argyro-Maria BOUTSI, Styliani VERYKOKOU, Fotis BOUREXIS and Chryssy POTSIOU, Greece

Key words: 3D modelling, Photogrammetry, Cultural Heritage, Visualization, VR, AR

SUMMARY

Photogrammetric surveying and 3D modelling are of immense value for the diagnosis and conservation of historic and religious buildings. In case they are coupled with eXtended Reality (XR) technologies (i.e., Virtual, Augmented and Mixed Reality), different levels of interpretation, interaction and dissemination can be achieved. This paper presents a holistic approach to the multi-representation of the restoration phases of a Byzantine church. The aim is twofold; the introduction of a low-cost photogrammetric methodology for a detailed and accurate 3D geometric documentation of CH buildings, and the development of a web-based integrated 3D platform with XR functionalities. The proposed methodology is applied to the external and internal 3D reconstruction of the 16th century old church (Katholikon) of St. Stephen's Monastery in Meteora, Greece, at two different periods: prior and after church maintenance work and restoration innervations. Close-range photogrammetry and computer vision are used for the collection of image data and the generation of dense point clouds, surface models and texture mapping. The final 3D models along with their supported metadata are integrated into an online XR viewer for a comparative temporal analysis through an immersive experience. The viewer has the following capabilities: (i) automated virtual tour on the 3D scene, (ii) points of interest, (iii) VR navigation as well as, (iv) marker-less AR based on hand pattern recognition. The 3D rendering and progressive loading, the interactive tools as well as the various visualization modes are built upon Three.js, Tween.js and AR.js libraries. The evaluation of the developed platform regarding performance and usability demonstrates the effectiveness of VR and AR in remote access, monitoring and preservation of tangible Cultural Heritage.

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1. INTRODUCTION

Advances in Photogrammetry, Computer Vision and immersive web technologies are transforming the way people percieve Cultural Heritage. 3D geometric documentations extend their scope to include dissemination strategies, engaging storytelling and simulation of on-site experiences. Besides entertainment and education, the metric and visual accuracy of the final products is valuable for a variety of critical purposes and uses, including preservation, reconstruction, reproduction and damage assesement (Waas and Zell, 2013; Barsanti et al., 2014). In case of restoration and preventive maitenance, the spatial dimension must be enhanced with an extra attribute, time. The 3D documentation of the current state determines with geometric precision the decay and deterioration of structural elements, architectural details and decorations. Considering that any intervention should be revesible, it is essential to document any minor or major repair carried out at regular intervals by the conservation professionals. Therefore, the recording of the restoration stages accounts for the need to retrieve and assess a priori phases and the facilitation of maintenance planning, interpretation and collaboration.

Ample research and studies have been published showcasing the high potential of photogrammetry, remote sensing and 3D modelling to restore heritage buildings (Golovina and Kanyukova, 2016; Genin, 2019), archaeological and historic sites (Remondino and Campana, 2014; Bianchi et al., 2016; Bryan, 2017), paintings (Abate, 2019), sculpures (Apollonio et al., 2017) and more. However, only a few approaches can be considered as complete in terms of sharing and communicating the results to potential visitors though immersive environments. Banfi et al. (2019) developed a scalable cloud platform for the visualization of the Basilica of Sant'Ambrogio in Milan and the dissemination of validated research exploiting gamification mechanisms, Virtual Reality (VR) and Augmented Reality (AR). More recently, a methodology for the documentation of dilapidated monuments through VR, the 3D reconstruction of their missing parts and their virtual restoration was applied in the church of St. Augustine in the city of San Cristóbal de La Laguna, Tenerife (Soto-Martin et al., 2020). A more promising line of research is the exploitation of WebXR to embed VR and AR technologies into a single, cross-platform interface for a seamingless experience (White et al., 2007; Carrozzino et al., 2019).

The plethora of conservation projects in literature showcases that a specific 3D survey has to be made and followed adhering to the characteristics and specialties of the monument in consideration. Effective monitoring has also to uphold time as well as any change concerning erosion, ageing, defects or human actions in accordance with the conservator's guidelines. Therefore, built heritage with complex structures, geometric peculiarities and details pose significant challenges to the whole process. Example of such a signature historic building and case study of the presented work is an Orthodox church building, the old church (Katholikon) of St. Stephen's Monastery located in the UNESCO site Meteora, Greece. Its maintenace work was conducted in 2019 by a multidispiplinary team which preserved all of the original elements and late harmonic interventions of the church.

The aim of the presented work is twofold: the 3D documentation of complex historic buildings for the recording, analysis and monitoring of temporal changes and the cross-platform XR (eXtended Reality) visualization of the produced datasets. To reach this aim, a low-cost methodology and photogrammetric workflow are proposed based on the indoor and outdoor 3D geometric documentation of the church through close-range and aerial photogrammetry at two time periods, before and after restoration works. The produced 2D and 3D geometric data of high precision and visual quality depict the enhanced color of mural paintings and frescoes, the repointing and the reproduction of the original mouldings after maintenance work. With the 3D models of the a priori and the current state as an entry point, the developed platform merges different types of integration, visualization and interaction to represent all the potential dimensions and stages of the visitor's experience. XR corresponds to the creation of VR and AR immersive environments. Particularly, the following functionalities are developed:

- Multi-resolution viewer for the general, AR and VR display of the textured and high-resolution 3D models with minimum loss in visual quality of the original data.
- Virtual self-guided tour in the church in first-person perspective camera view with highlighted points of interest, multimedia incorporation and 3D graphics as guidelines.
- Virtual automatic tour in the church through the animation of the camera motion with explanatory subtitles.
- Web VR free exploration of the interior of the church with a dedicated device.
- Marker-less WebAR based on user's hand tracking and pose for the interactive inspection of the church in the real environment of the user.

Moreover, the users can switch between the interior's restoration phases and the exterior of the church in real time and utilize the integrated services via the browser of any devise with network connection. The platform is developed with a combination of Three.js and other open-source JavaScript libraries on top of WebGL API and WebXR interface.

2. METHODOLOGY

2.1 Geometric documentation

The geometric documentation of cultural heritage buildings requires the acquisition and processing of the necessary imagery and geospatial data for the determination of their position, shape and size in the 3D space at a particular moment in time. The usual outputs of geometric documentation of cultural heritage buildings consist of orthoimages, 2D vector drawings and 3D models (point clouds and meshes) (Ioannidis et al., 2016). It is an essential task that forms the necessary background for the preservation of such cultural buildings, as well as for maintenance and restoration works. The products of geometric documentation may also be used as the basemap for studies of several specialists, e.g., architects, structural engineers, conservators and material engineers.

The geometric documentation of cultural heritage buildings is usually performed via combination of surveying and photogrammetric techniques, monoscopic (e.g., orthoimage), stereoscopic (e.g., stereo-restitution) and multi-image (e.g., image-based 3D modelling). The compined use of terrestrial laser scanners may also be applied for the scope of 3D documentation. However, taking into account the fact that laser scanning is a rather costly solution, it may be replaced by image-based 3D point cloud generation via Structure from Motion (SfM) and Dense Image Matching (DIM) techniques.

The necessary equipment for the geometric documentation of the internal space of cultural heritage buildings through a photogrammetric workflow combined with field surveying consists of Total Station and camera equipment and optionally lighting equipment, artificial targets and terrestrial laser scanner along with retroreflective targets. In case of geometric documentation of the external space of the cultural building, an unmanned aerial vehicle (UAV) along with GPS equipment may be additionally required. The data capturing process consists of the establishment of a geodetic network and the measurement of ground control points (GCPs), including artificial targets and/or natural features easily recognizable in the images and the acquisition of images and/or video sequences of the building.

After the data capturing process in the field, the photogrammetric processing follows. A SfM process is usually applied for determining the camera exterior orientation parameters and estimating the 3D scene geometry in the form of a sparse 3D point cloud. The first step of SfM is the extraction of features in each image. Image matching combined with outlier removal techniques follows and the extracted correspondences are organized into tracks. An incremental, hierarchical or global SfM method along with bundle adjustment procedures follows. Georeferencing of the SfM results is generally performed by a 3D similarity transformation between the arbitrary SfM coordinate system and the world reference system using GCPs. The generation of a dense point cloud through DIM is the next step. In case of availability of a laser-based point cloud derived by a terrestrial laser scanner, the processing of the laser-based scans including their registration using common targets as well as their georeferencing, using the measured coordinates of the targets, is also required. In this case, either the laser-based point cloud may be only used – instead of a DIM procedure – or a fusion of image-based and laser-based point clouds may be performed for filling of gaps of any of the point clouds. This fusion includes registration and merging of image-based and laser-based point clouds using common points and complementary fine registration techniques, like the ICP algorithm, as well as removal of wrong and noisy cloud points. The conversion of the dense point cloud into a mesh representation and the texturing of the derived mesh are the final steps of the multi-view stereo (MVS) pipeline. Several software packages (e.g., Agisoft Metashape, RealityCapture, Pix4Dmapper, PhotoModeler, iWitness, SURE, MicMac, VisualSFM, Meshroom, PMVS) have been developed for image-based creation of 3D point clouds and meshes, exploiting the MVS scheme.

The final products of the geometric documentation may vary, from 3D models to orthoimages or vector drawings. 3D textured models are derived through the MVS approach. The creation of orthoimages is accomplished through differential rectification. It requires knowledge of the camera interior orientation, the exterior orientation of the image or images used for the generation of the orthoimage or mosaic and the digital surface model (DSM) of the region depicted in the image or images. These kinds of data are outputs of the SfM and DIM processes. Sections of a cultural heritage building in the form of 2D vector drawings are also common products of geometric documentation, usually generated by manual or semi-automatic digitization using orthoimages as background. Less common is the use of a stereo-orthoimage, i.e., a stereo-pair consisting of orthoimages, which enables stereoscopic observation for digitization purposes (Ioannidis et al., 2016).

2.2 Web Extended Reality

2.2.1 Design principles for Cultural Heritage

The heterogeneous and rich dataset of the 3D geometric documentation of a cultural heritage building has to be intregrated in an online system in order to convey the spatial and temporal restoration changes as well as any other type of information that clarifies its architectural, historic or religious values. The design, the content and the services of the platform are determined by its scope, the type of data and the target audience. Despite the scientific nature of the project, the platform is also intended to serve and appeal to tourists, children, cultural heritage stakeholders and any other simple user and potential visitor. A balance must be achieved between multidisciplinary research tools and engaging user scenarios of educational and entertaining purposes. Immersive web technologies not only enhance perception and interpretation, but also increase retention of knowledge and immediate engagement (Bekele et al., 2018). The term of eXtented Reality (XR) embraces all aspects of mixed/mediated reality involving Virtual Reality (VR), Augmented Reality (AR) and Merged Reality (MR). In VR the entire scene is digitally created and enclosed in a virtual space on the screen while AR captures the real-life environment with a camera and augments it with computer-generated imagery. For the maximum exploitation of their capabilities for Cultural Heritage, it is proposed that both a VR and an AR session are integrated in the same interface. This type of system is governed by usability and accessibility issues, bandwidth limitations and technical considerations that need to be adressed. Navigation and interaction in a virtual enviroment can confuse or distract the non-familiar users. The specialized gear, the CPU - GPU computing resources or the software dependencies needed by the majority of XR applications act as a deterrent for experiencing of their full potential. However, the main problem lies on the size and resolution of the input 3D models and their texture images correspondingly. Depending on the GPU capabilities of the target hardware, a polygon count over 2M and 32-bit texture formats may decrease performance. While the maximum frame rate is 60 FPS (Frames Per Second), the achieved resolution at less than a half of the native frame rate for the given device, delays loading and degrades the original visual quality. Such a visualization is not appealing and inconsistent with the scope of the Cultural Heritage platform and the nature of the geometrically accurate and photorealistic data.

The current work aims to resolve these difficulties. The proposed system is cross-platform, accessible from any devise, ranging from low-range smartphones to high-end working stations. The integrated visualization modes and functionalities are based solely on web technologies and native device features, without external software dependencies. The platform is easy to use with intuitive interactions and clear user senarios taking into consideration non-experts and non-familiar with the XR functionality users. In order to get good performance and visual quality across low-end GPU machines, , a progressive loading approach, introduced by Visual Computing Lab of CNR-ISTI is employed (Ponchio and Dellepiane, 2015). Nexus converts the 3D data to a multi-resolution scheme that splits geometry into patches of different levels of detail and transmits only the nessecary for the current view ones. The view-dependent resolution allows the gradual refinement of geometry, fast streaming and adaptive rendering for consistent and high frame rates (more than 30 FPS). Finally, the developed features and tools, namely the dynamic display of restoration phases, the availability of multiple points of view and types of virtual walkthroughs and the multimodal information retrieval from the 3D scene, align to the platform's scope and the principles of digital conservations.

2.2.2 Web AR and VR

The developed system integrates three session modes with scalable levels of immersion: WebGL 3D visualization, Virtual Reality enabled by WebXR and Web Augmented Reality. It is a high-level websitebuilt with the traditional front-end technologies, namely JavaScript, HTML and CSS. Bootstrap framework is used for a responsive and mobile-friendly Graphics User Interface (GUI) while JQuery for event handling and synchronization. Three.js library is the core of the visualization scheme in which any plugin, extension and specialized library is bundled. It is an open-source 3D graphics library for the construction of 3D scenes in the context of a complete scene-graph scheme and an imperative API. The adaptive rendering and progressive loading are provided by the Nexus loader that integrates seamlessly to Three.js. Figure 1 illustrates the functionalities with their corresponding technologies and examples of the functions used. Tween.js library configures camera's position, field of view and aspect ratio to achieve its smooth motion through a specific path in the 3D scene. The easing method that determines the way the interpolation between values is performed, is <Quadratic.In>.

The VR session is supported by the emerging WebXR API, which enables web content to interface with mixed reality hardware. In the platform, the rendered scene is presented within the context of the website and requires a WebXR compatible browser or a device such as 3D headsets with motion and orientation tracking. When the VR session starts, the WebGL renderer of Three.js enables the XR rendering and the animation loop is adjusted accordingly. WebXR controls the timing, scheduling, and the various points of view relevant when drawing the scene while Three.js is responsible for loading, rendering and managing its components. A single room object with lines to indicate floor and extra lights are added to the VR scene while a ray tracing script tests for objects intersection in the Z space. Finally, AR.js and Handtrack.js libraries are utilized for the marker-less AR functionality based on hands tracking and recognition (Dibia, 2017). Tracking is supported by artoolkitjs5, a global dependency of Ar.js and part of ARTooliKit, a long-established native cross-platform AR library. To ensure responsiveness and attain more than 40 FPS on mobile devices, the 3D overlays are low polygon-count models (40K polygons), texture maps are compressed under 10 MB and shadow maps are used in combination with bake lighting. The AR output is rendered by Three.jsand superimposed via the camera of the user's handheld mobile phones or tablets on top of the detected user's hand. Handtrack.js uses a trained convolutional neural network (CNN) that provides bounding box predictions for the location of hands in an image. The hand detection model is exploited to detect and export the known hand pattern in a sequence of frames of the video, get the center of the palm to render the 3D model and ensure continued tracking in the case of occlusion.

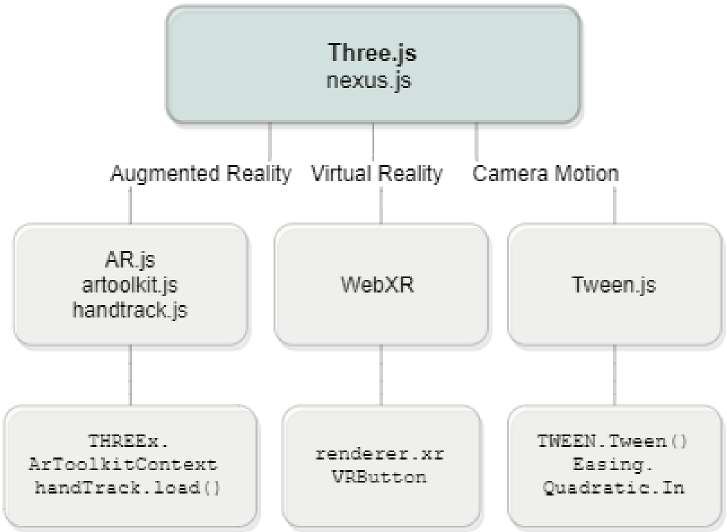


Figure 1. Overview of the system's main components.

3. IMPLEMENTATION

3.1 Case study and data collection

The proposed methodology for the 3D geometric documentation and the developed web-based XR platform are applied to the old main church (Katholikon) of the Monastery of St. Stephen, located at the southern part of the Archaeological site of Meteora, Greece. The Monastery of St. Stephen was established in the 14th century and is by far the most accessible monastery in the monastic complex of Meteora. It includes two cathedrals. The old church (Figures 2 & 3) was founded in the 15th century and renovated in the 16th century. This church, which is the case study of our research, is a small, single-naved basilica with narthex and a wooden roof. The church was hagiographed shortly after 1545. Its frescoes constitute an interesting sample of post-Byzantine hagiography. However, several damages were caused in the frescoes during the last war, including the faces and especially the eyes of all the saints. Despite this fact, the sacred representations create feelings of contemplation in the pilgrims (Meteora Thrones, 2020; https://www.kalampaka.com/en/meteora-monasteries/monastery-of-saint-stephen/). It constitutes a church of interesting geometric characteristics, as the biggest part of its southern side (2.5 – 3.2 m in height) is carved into a rock. The dimensions of the old church of the Monastery of St. Stephen are 11 m × 4 m. In the western side of the old Katholikon, there is an old tank and a room of an area of 6 m × 4 m, which is used for the needs of the church.

Figure 2. Left: An aerial image of the monastery of St. Stephen; its old church (Katholikon) is outlined in red. Right: View of the 3D model of the exterior of St. Stephen's church, depicting its southeast facade.

Figure 3. 360◦ panoramic image (left) and a photo (right) of the interior of St. Stephen's church.

(a) **(b)** **(c)** **(d)**

Figure 4. (a, b): Photos during the revelation of a niche in the north wall of the church; (c): the corresponding view of the 3D model after the restoration works; (d): zoom-in view of an image acquired during the maintenance works on a mural.

The maintenance and restoration works, conducted in 2019, included cleaning and conservation of the frescoes and murals of the church, replacement of carving, piercing into existing stonework, repointing, reproduction of original mouldings and renewal of door and tracery window surrounds (Figure 4). A very precise and careful preservation of all original elements of the old church was carried out and harmonic interventions were implemented. Contemporary means and techniques were used to recreate the spatial features of the old church and only elements with indisputable evidence were restored, avoiding any hypothetical restoration. The new materials barely touch the original structure of the church and the contact is as minimum as possible. All interventions are reversible and the original substance has been protected from further damaging.

The data capturing process took place at two different time instances: before and after the church maintenance works and restoration interventions. Specifically, 2300 images were captured in 2018, before the maintenance and restoration works, covering the internal space of the old church along with the old tank and the room at the western side of the Katholikon, for the scope of a detailed geometric documentation. After the restoration works, 1060 images were captured in 2019, depicting only the inner space of the church, where the maintenance works took place. All images were acquired by a Canon EOS 6D camera featuring a 24 mm focal length lens. The images correspond to a pixel size of 6.7 μm and a resolution of 5472×3648 pixels. 43 GCPs corresponding to both artificial targets and easily recognizable natural features were measured through Total Station equipment. Also, 1450 oblique and vertical UAV images by a DJI Phantom UAV along with terrestrial images by the Canon EOS 6D camera were acquired, covering the external part of the church.

3.2 Processing and products

A graphical representation of the entire workflow for data capture and derived products is illustrated in Figure 5. The Agisoft Metashape software was used for the photogrammetric processing of the images depicting the interior of St. Stephen's church both before and after the restoration works. The processing of the images of each time instance was performed separately, within different Metashape projects. SfM was the first step performed by Metashape. GCPs were manually measured in the corresponding images. The bundle adjustment resulted in RMS errors of 4.5 and 5 mm for the GCPs, and 1.6 and 1.3 pixels for their image measurements, for the first and second time instance, respectively. Furthermore, some regions of a few images (e.g., artificial targets, obstacles, etc) were masked, in order to reduce the subsequent editing of the resulting point clouds. DIM was the next step applied within Metashape. The Geomagic Wrap software was used for editing the resulting point clouds, through the removal of wrong and noisy cloud points. Furthermore, this software was used for 3D surface reconstruction through generation of one mesh for each time instance. In order to produce a 3D model textured in high resolution for each time instance, each generated 3D model was separated in about 10 meshes for each time instance (each one corresponding to a size of about 50MB), which were inserted into Metashape for texture mapping. The separate textured meshes were merged within Geomagic Wrap, resulting in a textured model of about 980MB for each time instance. The texture atlases of the 3D models were processed via the Adobe Photoshop software.

Figure 6 illustrates a view of the 3D model before the restoration works. Also, the 3D model of the external of St. Stephen's church (Figure 2 right) was generated via SfM, DIM and meshing techniques, similarly using the Agisoft Metashape and Geomagic Wrap software solutions.

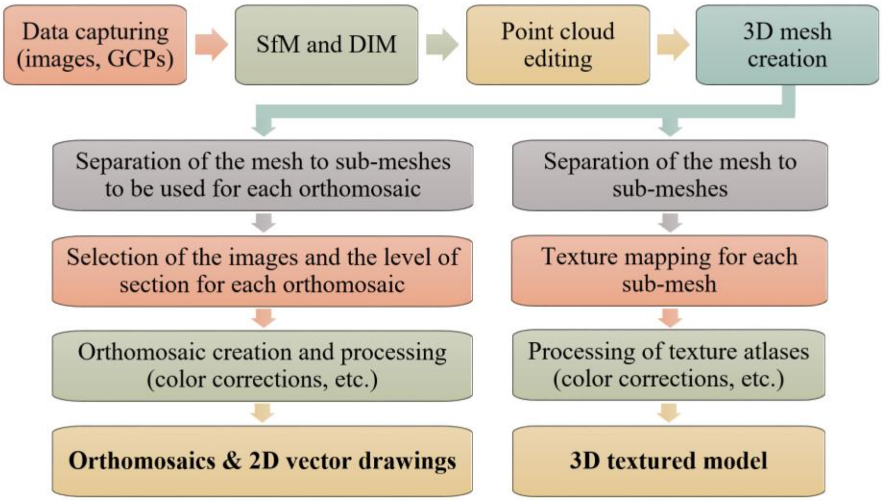


Figure 5. Workflow for the creation of geometric documentation products.

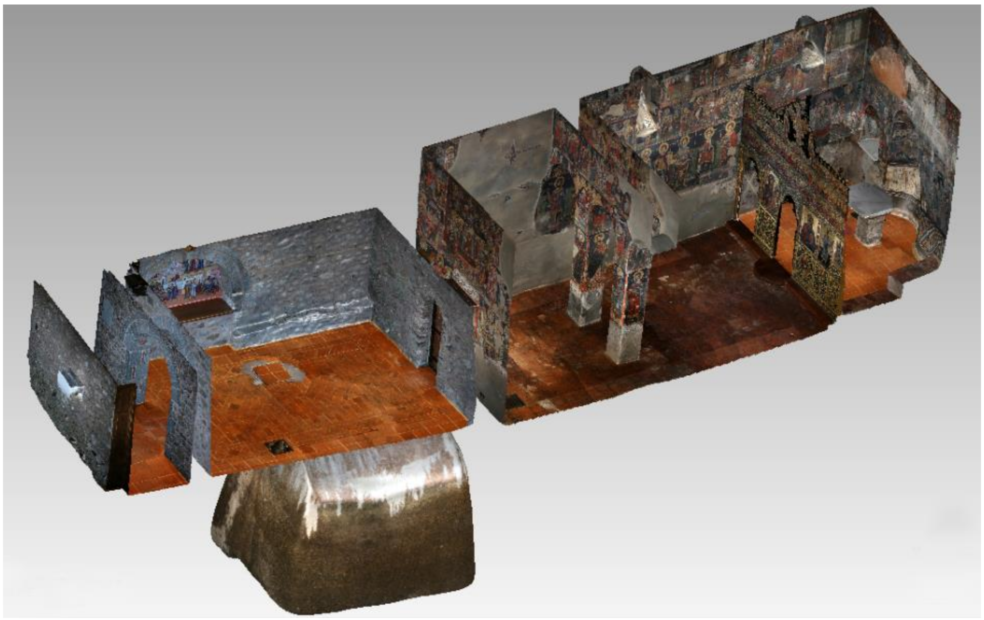


Figure 6. View of the 3D model of the church of St. Stephen before the restoration works.

Except for 3D models, orthomosaics at a resolution of 0.5 mm for the interior (e.g., Figure 7) and 1 mm for the exterior (e.g., Figure 2 right) of the church were created via Metashape, using the oriented images and the generated 3D models, by manually determining the level of section for each orthomosaic. The best images for each orthomosaic were manually selected and additionally parts of them corresponding to obstacles or parts of images of poor quality were masked. The derived orthomosaics were processed via the Adobe Photoshop software. Finally, 2D vector drawings of the internal walls of the old church as well as the external facades were generated for the scope of geometric documentation.

Figure 7. Northern section of St. Stephen's church before (top) and after (bottom) the restoration works.

3.3 XR viewer development

The platform is consisting of two main components: the user interface and the XR viewer that handles all the developed functionalities illustrated in Figure 8. The 4D viewer and the navigation tools do not require any specialized hardware, besides access to a browser on desktop or mobile.The 3D models of the interior of St. Stephen's Katholikon before and after the restoration work are imported to the Three.js framework as custom Nexus geometries. The default and most basic visualization mode is the free exploration of the 3D models using the trackball for pan, zoom, and rotation of the camera view. The standard perspective camera is the optimal option for viewing the church in a distance. Since the display system permits the dynamic switch between the two church's states and the inspection of temporal changes, it can be characterized as 4D.

The navigation tools offered within the context of the browser, are the self-guided virtual tour and the automatic virtual tour. The first one alters the viewpoint to an intuitive and natural perspective. It aims is at simulating the user's vision for a natural perspective of walking around the church. The first-person camera is placed on a height above ground level alongside an "invisible" character and the navigation works with arrow keys or mouse movement. A 3D arrow indicates their orientation relative to the scene in order to increase the sense of spatial awareness. The highlighted geometry is clickable and serves as an annotation tool for points of interest. The visitors can get information about the architectural features, the structure and the state of conservation with the impression they are navigating to the church themselves (Figures 9 & 10). The second one is an automatic navigation to the church through a predefined path that gives the opportunity to the user to explore it in short time. Every frame is enriched with brief descriptions in the form of subtitles imitating a narrative storytelling. Sequential seamless animations of the camera start from the entrance and the porch and continue to the water tank that is located underneath the narthex until the camera frames the nave, the main body of the church. After a close-up to the iconostasis, the camera goes through it to frame the sanctuary and the tour ends up at the small chiseled rock room used to be an ossuary (Figure 10).

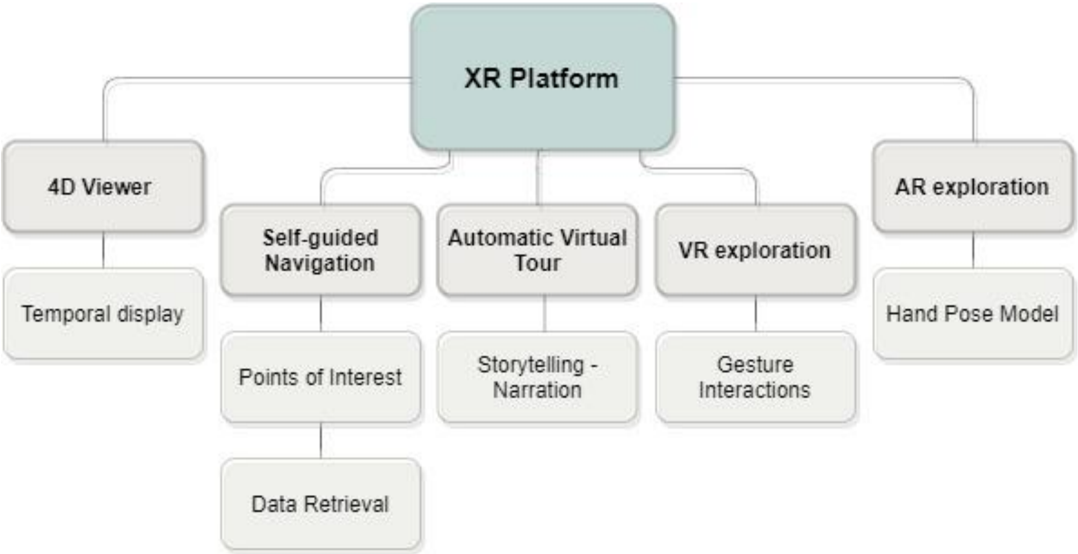


Figure 8. Overview of the componets and functionalities of the platform.

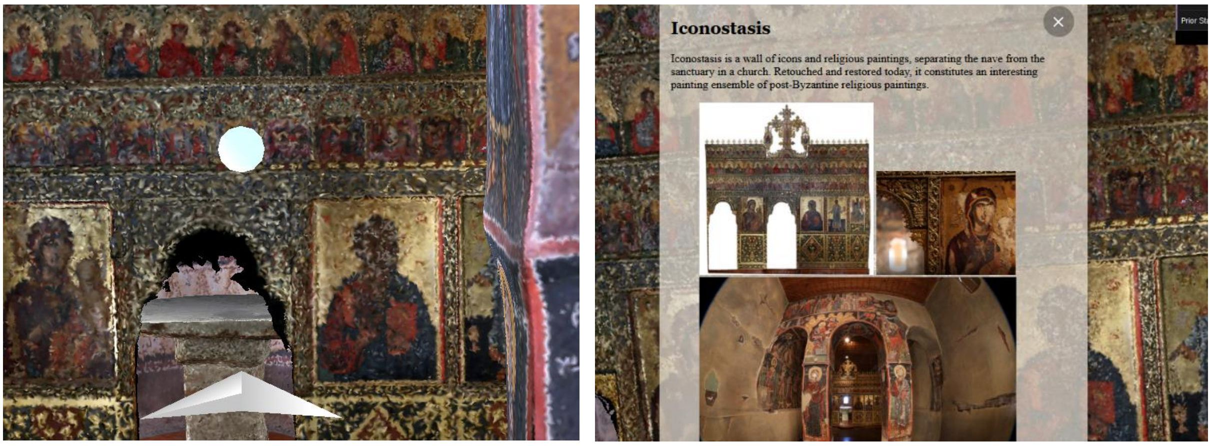


Figure 9. Snapshot during the automatic navigation while camera frames the iconostasis (left) and modal with information about the icocostasis when user clicks the hotspot (white circle in the left image).

The VR mechanism entails the use of specialized gear in order to attain the maximum degree of immersion. However, Chrome browser provides the WebXR API emulation plugin that allows users to move and rotate a VR headset virtually. Once enabled, the system checks if any device or emulator is connected and once detected, a message indicates VR compatibility and the 3D model can be explored within the VR space. A camera crosshair helps users orient to the camera's point of focus while the floor and the walls are outlined. Finally, the augmentation of the real environment with the 3D model of the church adopts a pattern-based paradigm in which instead of image or marker tracking, hands undertake the role of the physical anchor to the digital content. A hand detection model and a robust tracking mode allows continued pattern tracking in the presence of significant occlusion. When AR is activated, the system checks the availability of camera and asks permission to access it. Then, the user follows the instructions that overlay the camera feed, shows his/her hand to the camera with the palm facing up and 3D lines indicate the hand detection and tracking. The palm is used as an attachment point where the 3D model of the church is superimposed at a given pose (Figure 12).

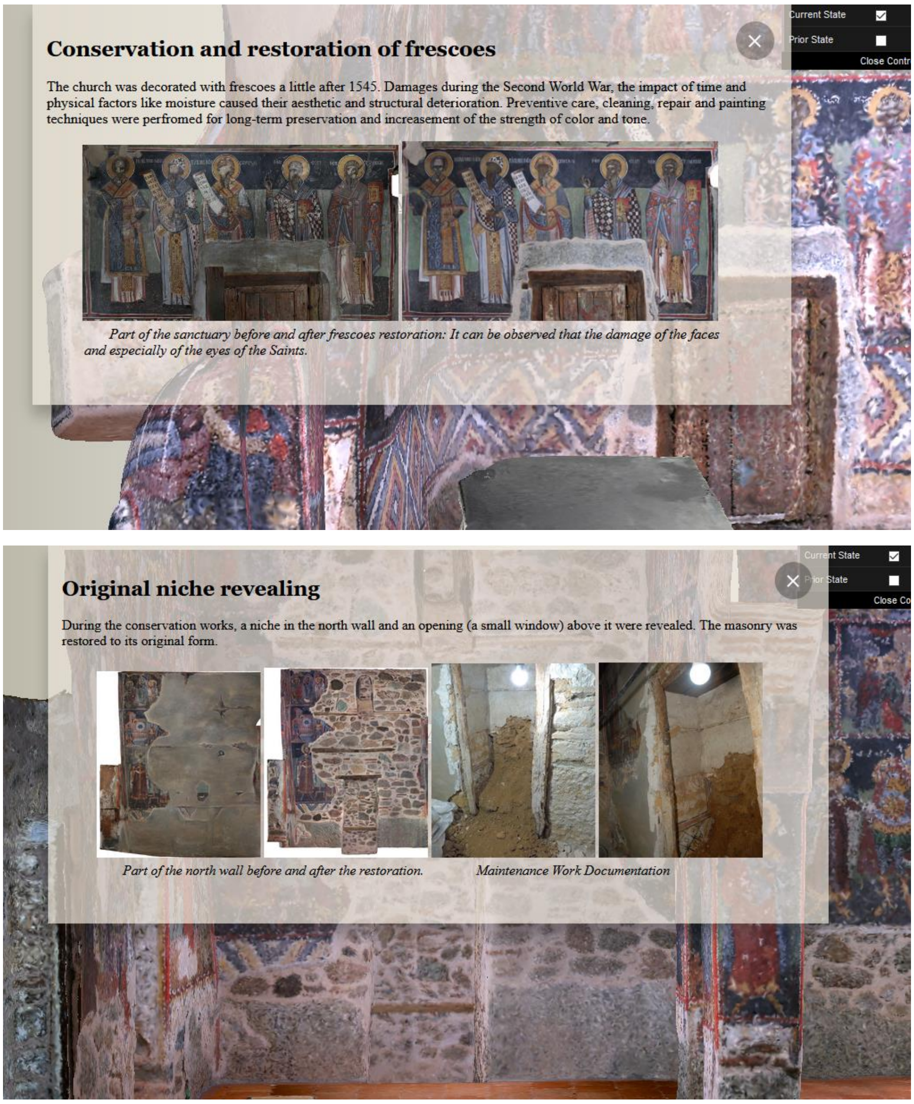
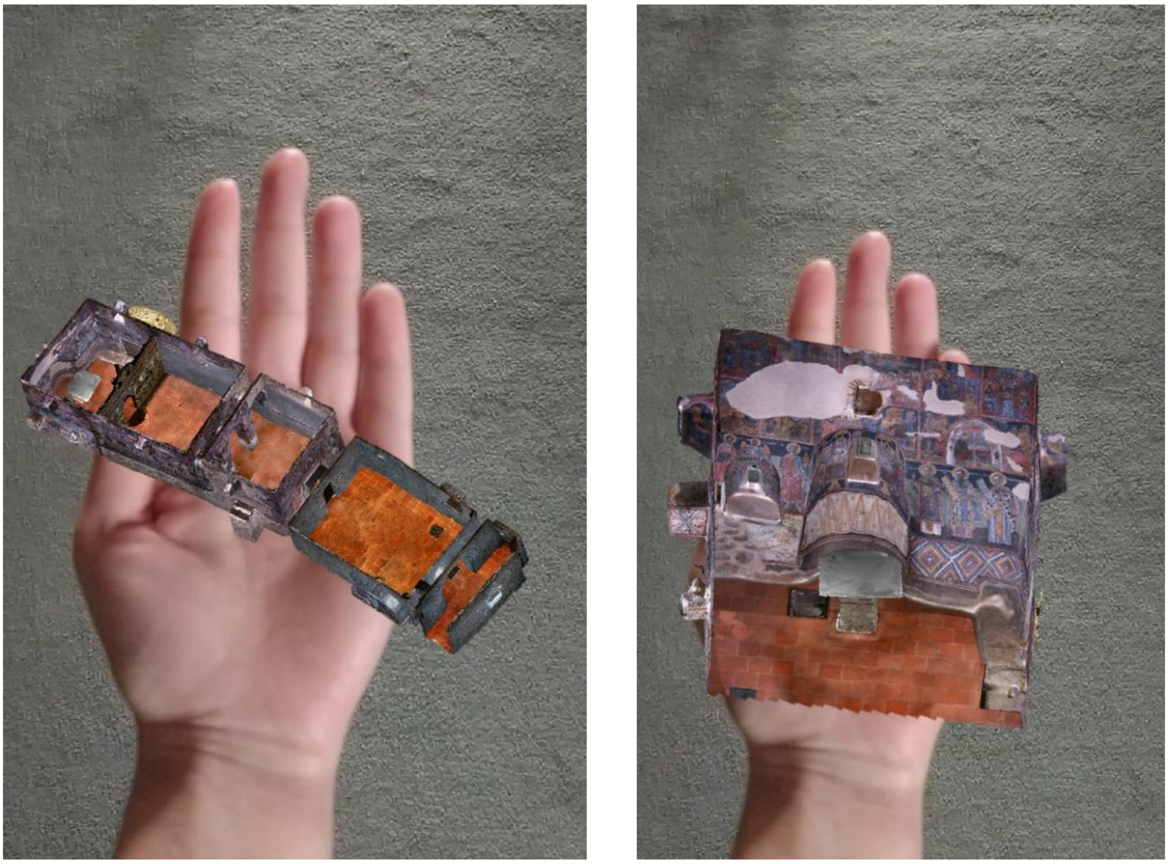


Figure 10. The interactive retrieval tool enables the access to multimedia during the self-guided tour: orthophotos, documentation images as well as brief descriptions are provided for (Top) the frescoes of the sanctuary and (Bottom) the niche of the nave.

Figure 11. The camera path of the automatic navigation tour through the various sections of the church.



(a) **(b)**

Figure 12. The 3D models of the church after restoration (a, b) are superimposed at the given pose on top of the user's hand. (a). Top view of the church, including the sanctuary, the nave, the narthex and the additional entrance hall. (b). Section of the sanctuary of the church; the square altar table or holy table can be seen in the center of the sanctuary.

4. CONCLUSIONS

A complete workflow for experiencing the restoration of an Orthodox church in a XR environment by using low-cost and open access technologies is presented in this paper. The workflow comprises image-based photogrammetry for data collection, computer vision techniques for the conversion of the images to 3D meshes and finally, all the procedures of visualizating and communicating the 3D and 2D content to a wider audience in the context of a cross-platform XR website. The proposed methodology lies on the two 3D geometric documentations carried out before and after the maintenace repairs of the old church (Katholikon) of St. Stephen's Monastery in Meteora. From 3D digitation to XR visualization, digital conservation, accurate recording of spatial and temporal resotration changes, knowledge sharing and simulation of on-site experience are addressed by the means of a single platform. It is designed to serve both the needs of researches, scientists and specialists of the field as well as simple users and potential visitors of the church. While WebXR API is still being refined, future work focuses on the progressive enhancement of the platform with more features and extended capabilities. Specifically, a back-end infrastructure will be developed and the AR functionality will be enhanced with user's screen interactions to manipulate the position, scale and rotation of the 3D models and/or annotations with text lables. To attain multiple levels of control and promote accessibility, the VR representations that are mirrored directly to the user's screen, will be optimized with movement, orientation and motion controls using keyboard and mouse. Thus, the VR sessions will be more engaging and immersive by recreating the utilities of headsets or other specialized gear.

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BIOGRAPHICAL NOTES

Charalabos IOANNIDIS

Dr. Surveying Engineer, Professor at the Lab. of Photogrammetry, School of Rural and Surveying Engineering, National Technical University of Athens, Greece, in the field of Photogrammetry and Cadastre. He is the Dean of the School and the Deputy Director of the Interdisciplinary Programme for Postgraduate Studies in 'Geoinformatics'.
He was the Chair of the Working Group 'Technical aspects of Spatial Information Management', Commission 3 of FIG (2011-2018). He is the Chair of the Working Group 3.2 'Geospatial Big Data: collection, processing, and presentation', Commission 3 of FIG (2019-2022). He was a member of the management board of the Hellenic Mapping & Cadastre Organization (1998-2001). He has given several lectures in national and international Seminars, in the fields of Photogrammetry, Geometric Documentation of Cultural Heritage, Cadastre and GIS. He has been the scientific responsible of 19 research projects and he has participated in more than 35 other research projects. He has written more than 200 reviewed papers in scientific journals, books and proceedings, and another 50 presentations in conferences. He serves as reviewer in various scientific journals, books and international conferences.

Sofia SOILE

Sofia Soile obtained a diploma in Rural and Surveying Engineering (1995), Master of Science (MSc.) in Geoinformatics (2013) from the NTUA. She is a member of the Lab. of Photogrammetry of the SRSE of NTUA teaching in undergraduate and postgraduate courses. She has a broad professional activity in the fields of Photogrammetry, and Computer Vision and she has worked as a Researcher in more than 40 Research Programs, aiming at the Photogrammetric Data Acquisition and Processing, 3D scanning via Laser Scanners, White Light Scanners, Handheld Scanners, 3D Modelling of Sites, Industrial Applications, Spaces and Complexes Objects, 3D applications for monument restoration, CAD modelling, 3D Inspection, Structure Monitoring, Deformation Analysis, Processing and Modelling of Point-Cloud Data, BIM Modelling, Computer Vision Techniques in Monuments, Multidimensional Spatial Systems Information, etc. She is co-author in more than 50 scientific papers in the fields of photogrammetry and compute vision, that have been published in peer-reviewed International Scientific Journals and Conference Proceedings.

Argyro Maria BOUTSI

Argyro Maria Boutsi received a diploma in Rural and Surveying Engineering from the National Technical University of Athens (NTUA), Greece, in 2019. She is a research member of the Laboratory of Photogrammetry of School of Rural and Surveying Engineering (SRSE) and she is currently pursuing a PhD degree in Augmented Reality from National Technical University of Athens. The subject of her doctoral dissertation is "Photogrammetric techniques and algorithms optimization for the development of interactive Augmented Reality systems". Her research interests lie in the fields of photogrammetry, augmented reality, computer vision and 3D computer graphics. She has one peer-reviewed journal article and six peer-reviewed conference papers on topics including 3D web visualization and computer graphics, web development and mobile Augmented Reality.

Styliani VERYKOKOU

Dr. Styliani Verykokou obtained a diploma in Rural and Surveying Engineering (2013) from the National Technical University of Athens (NTUA), Greece, achieving a grade of 9.29/10. She has been awarded several scholarships and awards by the National Institute of Scholarships of Greece, the NTUA, the Academy of Athens, the Technical Chamber of Greece, the Thomaidion Foundation (Greece) and the Limmat Foundation (Switzerland), as a result of her performance in her studies. She obtained her doctoral degree in Photogrammetry from the School of Rural and Surveying Engineering of NTUA in 2020. The subject of her doctoral dissertation was "Georeferencing procedures for oblique aerial images" and it was supported by the Eugenides Foundation scholarship. She has participated in several research projects in the fields of photogrammetry and computer vision and has authored more than 20 scientific papers in these fields.

Fotis BOUREXIS

Mr Fotis Bourexis is a Rural & Survey Engineer at NTUA with a Msc in Geoinformatics. He is a fellow researcher at NTUA and in parallel a freelancer with technical office in Tripoli, Arcadia, Greece. He is co-author in 7 publications in international journals and conference proceedings. He has participated in various case studies and more than 10 research projects in the fields of Photogrammetry and Computer Vision, with emphasis on the field of 3D object capture, 3D modelling and geometric documentation of cultural heritage monuments.

Chryssy POTSIOU

Chryssy Potsiou (http://users.ntua.gr/cpotsiou/) is a Dr Surveying Engineer, Professor, in the fields of Cadastre and Spatial Information Management, and Property valuation, at the School of Rural & Surveying Engineering of the National Technical University of Athens, Greece and FIG Honorary President. She has been member of the boards of the Hellenic Mapping and Cartographic Organization (2009-2012), Hellenic Association of Rural and Surveying Engineers, Hellenic Society for Photogrammetry and Remote Sensing, and the Hellenic Society for Geographic Information Systems.

She has been FIG Commission 3 Chair (2007–2010); FIG Vice President (2011–2014); FIG President (2015–2018); elected bureau member of the UNECE Working Party on Land Administration (2001–2018) and UNECE WPLA Vice Chair (2019–2020). She has published more than 200 peer reviewed papers.

CONTACTS

Prof. Dr. Charalabos Ioannidis
School of Rural & Surveying Engineering,
National Technical University of Athens
9 Iroon Polytechniou St.
Athens
GREECE
Tel. +302107722686
Email: cioannid@survey.ntua.gr
Web site: http://users.ntua.gr/cioannid/

Sofia Soile
School of Rural & Surveying Engineering,
National Technical University of Athens
9 Iroon Polytechniou St.
Athens
GREECE
Tel. +302107722651
Email: ssoile@survey.ntua.gr
Web site: http://users.ntua.gr/smsoile/

Argyro-Maria Boutsi
School of Rural & Surveying Engineering,
National Technical University of Athens
9 Iroon Polytechniou St.
Athens
GREECE
Tel. +302107722651
Email: iro_mpoutsi@outlook.com
Web site: http://users.ntua.gr/iboutsi/

Dr. Styliani Verykokou
School of Rural & Surveying Engineering,
National Technical University of Athens
9 Iroon Polytechniou St.
Athens
GREECE
Tel. +302107722687
Email: st.verykokou@gmail.com
Web site: http://users.ntua.gr/sveryk

Fotis BOUREXIS
School of Rural & Surveying Engineering,
National Technical University of Athens
9 Iroon Polytechniou St.
Athens
GREECE
Email: fotis.bourexis@gmail.com

Prof. Dr. Chryssy Potsiou
School of Rural & Surveying Engineering,
National Technical University of Athens
9 Iroon Polytechniou St.
Athens
GREECE
Tel. +302107722688
Email: chryssy.potsiou@gmail.com
Web site: http://users.ntua.gr/cpotsiou/