The First Attend for a Holistic HBIM Documentation of UNESCO WHL Monument: The Case Study of Asinou Church in Cyprus

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Abstract. The study examines the documentation of the Asinou Monument within the auspices of the H2020-SC6-R&I-INCEPTION project. The project focuses on the use of innovative 3D modelling of cultural heritage through an inclusive approach for 3D reconstruction of monuments, as well as the built and social environments over time. The project will enrich European identity by examining how European cultural heritage evolves over time. Therefore, data acquisition techniques and 3D reconstruction and modelling methodologies for data processing were examined using the Asinou Church as a case study. Asinou Church is a 11th century church located in the Troodos Mountains of Cyprus, which is a UNESCO World Heritage Site. This unique monument contains some of the finest Byzantine wall paintings in Cyprus which date between the 11th to the 17th century. Their outstanding historical value is very exceptional and makes their documentation a great challenge for the present ICT technologies. Different multimodal techniques, such as photogrammetry, laser scanning, image processing, video and audio were used for the data acquisition of all detailed features of the tangible building and the intangible story (liturgy). Following, the information was processed to create a 3D model in order to document the church using Building Information Modeling (BIM). The church was digitally reconstructed in a 3D BIM model, where it was then processed to produce a Heritage Building Information Model (H-BIM) in order to create a prototype for a holistic documentation and further study.

Keywords: H-BIM · EU-H2020 INCEPTION · Digital cultural heritage
Remote sensing · BIM · 3D model · UNESCO WHL · 3D reconstruction
Asinou Church

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1 Introduction

The study examines the documentation of the Asinou Monument within the auspices of the H2020-SC6-R&I-INCEPTION project for the development of a prototype cloud digital platform to interact with the end-user within a series of visual data and metadata regarding the monument.

The INCEPTION project[1] focuses on using innovative 3D modelling of cultural heritage through an inclusive approach for 3D reconstruction of artefacts, as well as the built and social environments over time. This outstanding project will enrich European identity by examining how European cultural heritage evolves over time. INCEPTION provides state-of-the-art 3D reconstruction by utilizing innovative procedures for 3D laser survey, data acquisition and processing. In this way, the accuracy and efficiency of 3D capturing is improved through the integration of Geospatial Information, Global and Indoor Positioning Systems (GIS, GPS, IPS) through hardware interfaces and software algorithms. The INCEPTION methods are used to create 3D models that are easily accessible and interoperable with different hardware and software. As well, the INCEPTION project has developed an open-standard Semantic Web platform for Building Information Models for Cultural Heritage (HBIM) that will be implemented in user-friendly Augmented Reality (VR and AR) operable on mobile devices.

In this case study, the semantic development of the different entities and objects that make up the construction of the Asinou Church and the interior, including wall frescoes and the 3-D space create a knowledge base for the research of the Asinou Church. The idea of using digital technology to document cultural heritage in all aspects, both tangible and intangible heritage within a structure, creates a dynamic repository and valuable resource to better understand the cultural heritage monument, as end-users will have the ability to access the information from the digital platform at any time [1–5].

Different techniques, such as photogrammetry, laser scanning, drones, video and images were used for the data acquisition of all features of the church, which were then processed to create a 3D model and document the church using Building Information Modeling (BIM). The church was digitally reconstructed in a 3D BIM model, which was then processed to produce a Heritage building Information Model (H-BIM) in order to create an information database for further study.

2 Study Area

The study area is the monument of Panagia Phorbiotissa, also known as Asinou Church (Fig. 1), which is a small 11th century church dedicated to the Virgin Mary. The church is located in the north foothills of the Troodos Mountains of Cyprus, which is a UNESCO World Heritage Site [6]. The monument was built at the end of the 11th century and was a monastery church until the end of the 18th century, when it was abandoned. The church consisted of a vaulted single-aisled nave and the narthex that

[1] www.inception-project.eu.

was added in the second half of the 12th century. The structure was built with mud mortar and has experienced frequent collapses and reconstructions.

Fig. 1. The Panagia Phorbiotissa monument - Asinou Church

The interior of the church is entirely covered with over 100 frescoes from the 12th–17th Century and are considered some of the best examples of Byzantine mural paintings in Cyprus. Many of the original wall-paintings from the 12th century, are in the apse of the Holy Bema and the west wall of the church, which suffered damages especially from earthquakes. During the 14th century, the conch of the apse was rebuilt and the external buttresses were added The narthex was redecorated in 1332/3 following strong Frankish influences [7].

3 Methodology

Following a phase of a detail data acquisition procedure (geometry, materials, etc.) a Building Information Modelling (BIM)[2] is used for design and management of projects in the built environment industry. BIM is a collaborative model where multiple team members can work on a project at the same time. BIM provides a multi layered, multi-dimensional, multi-disciplinary, parametric, smart and informative digital model of a project.

Building Information Modelling (BIM) workflows provides the capability to document cultural heritage buildings in order to facilitate the existing building model

[2] https://en.wikipedia.org/wiki/Building_information_modeling.

structure with the information collected from the cultural heritage building in order to create an integrated HBIM (Heritage Building Information Model) (Fig. 2).

Fig. 2. HBIM strategy

HBIM includes all the information and parameters from the cultural heritage building, including building components, structural elements, materials and semantic information. The development of such an information management model was the basic tool in order to construct and develop the H-BIM of the Asinou Church.

In the Asinou Church case study, the BIM workflows and the BIM 3D model were developed using 3D laser scans, point clouds and UAV data of the topography of the church [6, 8]. Using BIM software, the survey data, together with the data from the laser scanners' millions of data points and images from the site were used to process the data and develop a point cloud of the church [9]. The point cloud to BIM modelling utilizes state-of-the-art technology to convert the point cloud and laser survey data into accurate 3D BIM models (Fig. 3). Point cloud to BIM modelling are considered to be more accurate than traditional surveys using measuring tools. The 3D BIM model created from laser scan and UAV data was integrated with the building semantic data, providing information, such as construction materials, condition, color, texture, etc.

Fig. 3. 3D model elevation, generated by point cloud (Color figure online)

The 3D BIM model resulted from the survey data using laser scanners and photogrammetry documented the existing condition of the Asinou Church with a scale of 1:1 in order to integrate all the metadata collected from the building. The methodology used to document the church included:

1. 3D building documentation of the existing church (3D)
2. Date/time of construction of different aspects of the church (4D)
3. Quantity of the materials and structural elements (5D)
4. Model analysis and sustainability evaluation of the space and climatic conditions (6D)
5. Conservation and rehabilitation management (7D).

Figure 4 features the 3D development of the HBIM model.

Fig. 4. 3D development of the model

The resulting 3D HBIM has the ability to manage all the building information as a church and as a cultural heritage monument. The HBIM approach for documenting such cultural heritage monuments is the solution for managing tangible and intangible information that creates the narrative of the monument. The HBIM acts as a source of information which provides valuable data without the need of visiting the monument [5]. Figures 5 and 6 both feature sections of the model.

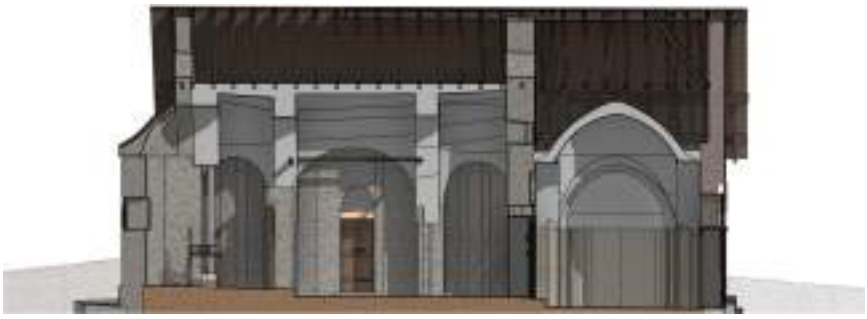

Fig. 5. 3D model section

Fig. 6. Section of 3D HBIM

4 Results

The first phase for the process of documenting, creating and implementing the methodology of BIM for cultural heritage monuments provides the opportunity of capturing the cultural heritage information for managing a HBIM holistic approach. In the case of the Asinou Church, the presence of the Byzantine frescoes in the interior space created the need for the collection of data in order to integrate the story of each

Fig. 7. Frescoes inside Asinou Church (Color figure online)

fresco into the building information regarding image, geometry, color, texture, etc. The entire church was modeled using HBIM so that all the frescoes covering the walls and ceiling of the church could be documented (Fig. 7).

The next step to the use of information is to extract that information to the user by using augmented and virtual reality technologies, thereby provided an added-value experience to the visitor.

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