PHOTOGRAMMETIC MODELING OF BYZANTINE CHURCHES

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ABSTRACT

The creation of the photorealistic models of two Byzantine churches was elaborated during a cooperation of the 5th Byzantine Ephorate of Greece, the Cultural and Educational Technologies Institute and the Department of Architectural Engineering of the Democritus University of Thrace under the funding of the European Union Framework Programme.
The creation of the outer surfaces of the 3D models was accomplished through the photogrammetric processing (using Photomodeler, 3D Builder and IRASC software applications) while the inner surfaces model was obtained through manual measurements and proper processing in a CAD environment (AutoCAD 2000). Using convergent photorgammetric software applications a complete textured 3D model was produced and further processing continued in 3D Studio Max for the creation of the animation series and VRML files. The texture images of the inner surfaces that are covered with fresco paintings were applied through proper processing in 3D Studio Max. Special processing and techniques were used for the correct registration of the texture images on the dome and arch structures that are present inside the churches.
The final products are going to be used for the virtual tour inside the churches and for the documentation of these very important monuments of Cultural Heritage.

1. INTRODUCTION

Photogrammetric modelling of buildings having great cultural value is becoming a common task during the last years (Balodimos,. et.al., 2003). It is not only a correct way for the documentation of the buildings but also a fast and easy way to the restitution of their basic geometric and thematic information.

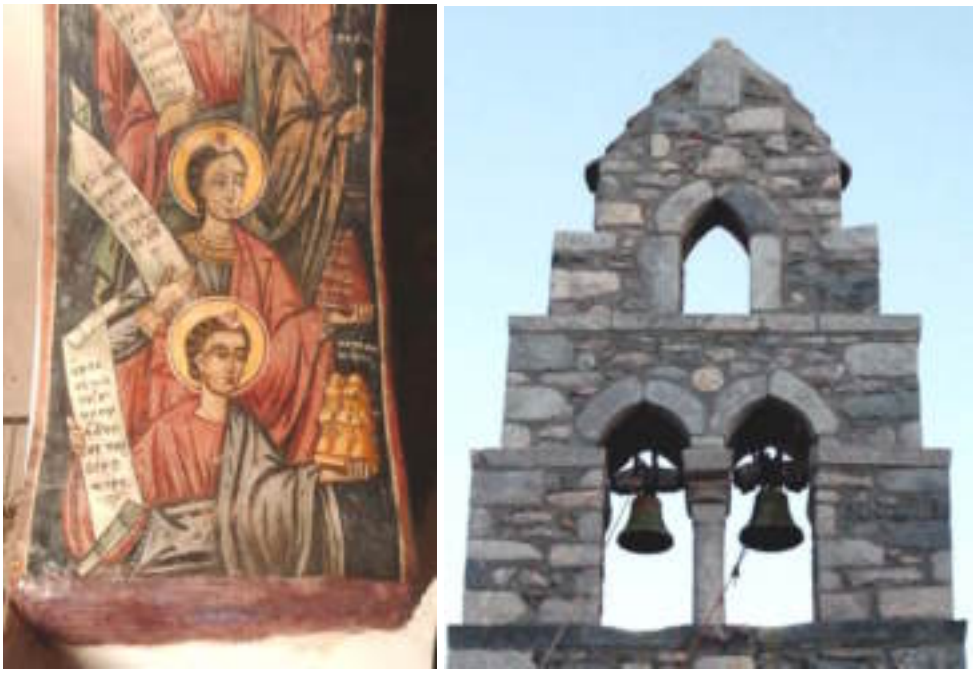

Fig 1. The temples are characterized of beautiful decorative constructions and paintings of great archaeological and relational importance.

Fig. 2. The photogrammetric processing was carried out rather easily using a bundle of images covering all around the entire buildings

The current paper is describing the recent attempt of three different institutes in Greece (the 5th Ephorate of Byzantine Antiquities, the Depertment of Architectural Engineering of the Democritos University of Thrace and the Cultural and Educational Technologies Institute of Greece) for the documentation of two Byzantine churches in one of the richest in Byzantine antiquities sites in Greece, Mani. The current attempt has been directed to the creation of the virtual models of the two buildings, giving the opportunity to potential visitors of the local museums and other people through the Internet to navigate inside and around them. The models are also giving the capability to relevant researchers and archaeologists in general to study the models and help them in their own research. The remote study of the models either from researchers or from everyday people was one of the main goals of the cooperation between the three above-mentioned institutes.

The two churches provide not only a typical form of several similar churches in the region but they are also internally decorated by a great number of fresco paintings. The decoration of the two churches is present also in their outer surface. Very unusual and beautiful anaglyph figures and paintings are present in both of them giving them great archaeological, cultural and mainly religious value (fig. 1).

2. BASIC PROCESSING

2.1. Photogrammetric Modelling

Although the laser scanning (Beraldin, et.al. 2002) would be the most appropriate method for the creation of the textured models of the two buildings, instead the photogrammetric modelling has been chosen due to the following reasons:

- low budget
- no demand of great accuracies of the derived documentation products

The 3D model of the outer surfaces of the two churches has been acquired through the photogrammetric processing of the images using two off-the-self, very well rated photogrammetric packages Photomodeler and 3D Builder.

The camera that was used for the image capturing of the photogrammetric images was a 6.3 Mpixel NICON D1X dSLR camera equipped with a 17mm wide-angle lens. Additionally, a second NIKON D1 dSLR camera was used just for the evaluation of its features. The cameras have been properly calibrated using the embedded module of the Photomodeler application. The calculated calibration parameters are illustrated in table 1.

Parameter	value	Std. Dev.
f (camera constant)	16.465255	0.003
xo (of principal point)	11.153535	0.009
yo (of principal point)	7.398465	0.006
Format width	22.594353	0.007
K1	3.418e-004	5.5e-006
K2	-1.092e-006	1.1e-007
K3	0.000	
P1	-1.013e-005	6.4e-006
P2	-1.547e-005	6.0e-006

Table 1. Calibration parameters

The photogrammetric processing was carried out rather easily and with no particular problems using a small number of measurements and a bundle of images covering all around the entire objects (fig. 2). Horizontal and vertical measurements of distances between well-distinguished and properly distributed feature points on the 3D objects gave the appropriate control for the registration of the images in the 3D space and the final calculation of the 3D model. Additional measurements gave the appropriate validation points in the photogrammetric processing.

The overall accuracy of the derived 3D model was 0.5-0.8%. The generated models were accurate enough for the production of satisfactory solid models that would be the basis of the textured Virtual Reality Model (VRML) of the two buildings.

2.2. Texture Mapping

The model was exported in DXF format providing all the basic geometrical features describing the entire 3D model. The final surface model was imported in 3D Studio Max where also the texture mapping was accomplished. The final texture images of the planar outer surfaces were produced in Z/I Imaging IRASC software application giving the best resolution of the rectified images that were applied on the models' surfaces.

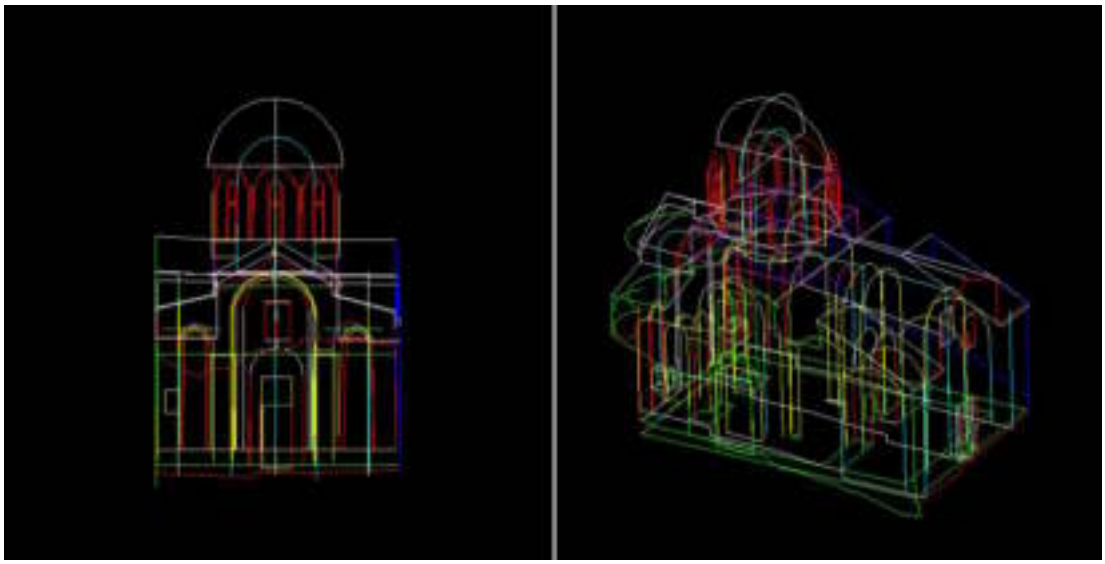

Fig 3. The wireframe model (front and isometric view) of one of the churches.

Photogrammetric image processing has also been applied for the creation of the photomosaics of the inner parts' textures. However, in this case, the measurements and the 3D model of the inner part of the churches, where acquired through manual measurements using a common measuring tape and a laser distance meter. The small size and convenient shape of the objects allowed the working team to use empirical procedures to generate the 3D model (fig. 3). The achieved accuracies were good enough to provide satisfactory solid models that were draped with the texture photomosaics. The rectified images of the planar surfaces of the walls were directly applicable on the models' surfaces and no problem was encountered during this process.

However, in the case of the curved surfaces (domes and arches), the creation of the textured images was not an easy job to do. Since the entire textured modelling was accomplished in 3D Studio Max the most appropriate way to drape the images on the curved surfaces was to manually register the best resolution images. The capturing of the curved surfaces' images was realized so that just a single image would be enough to map the entire curved surface. In only one case, an arch was modelled as an unwrapped semi-cylinder, so that several planar sub-surfaces described its entire surface. The generated image had the finest resolution across and along its dimensions providing the best texture image (fig. 4). The embedded processes of 3D Studio Max for registering texture images on curved surfaces obtained the final working textured model (fig. 5-8). Finally, the 3D model was exported in VRML file format. Additionally animation files have been produced providing a virtual tour inside and around the two buildings.

Fig.4. The arch's original and texture image. The texture image was produced as a photomosaic of rectified images of several different snapshots.

3. CONCLUSIONS

During the cooperation of three different institutes in Greece that are concerned, each one of them from a different perspective, with the preservation of the Greek Cultural Heritage, the photogrammetric documentation and photorealistic representation of two Byzantine churches have been realized. The aim of the cooperation was not only to provide a reliable textured 3D model of the churches but also the promotion and use of the new technologies to save the Cultural Heritage of Greece.

REFERENCES

Balodimos, D., Lavvas, G., Georgopoulos, A., *Wholly Documentation Holly Monuments*, Proceedings of the CIPA 2003 International Symposium: "New Perspectives to Save Cultural Heritage", pp. 502-506, Turkey, 2003.

Beraldin, J.-A., Picard, M., El-Hakim, S.,F., Godin, G., Latouche, C., Valzano, V., Bandiera, A., *Exploring A Byzantine Crypt Through A High-Resolution Texture Mapped 3D Model: Combining Range Data And Photorgammetry*, Proceedings of the CIPA WG6 International Workshop:"Scanning of Cultural Heritage", pp. 65-70, Greece, 2002.

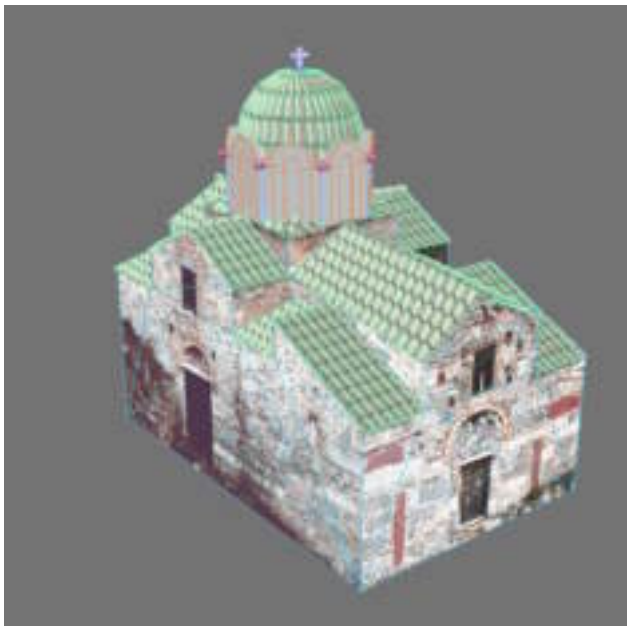

Fig. 5. Wireframe model draped with the texture images

Fig 6. Finally rendered model

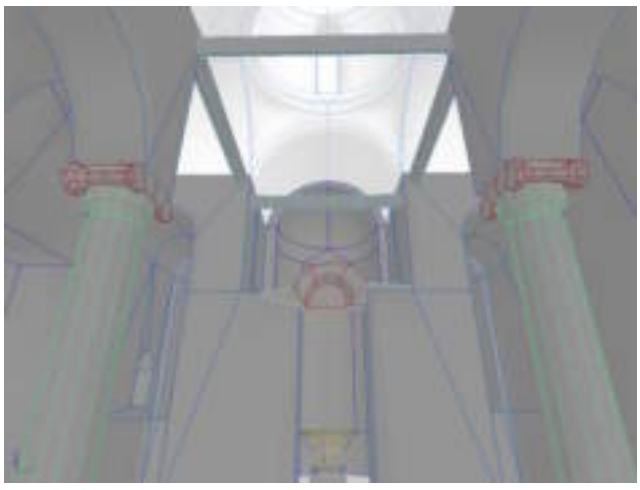

Fig. 7. Solid model of the inner surfaces.

Fig 8. Rendered model of the inner surfaces.