Exploring the Possibilities of Immersive Reality Tools in Virtual Reconstruction of Monuments

Panagiotis Parthenios[1] and Theano Androulaki[1,2(✉)]

[1] School of Architecture, Technical University of Crete, Chania Crete, Greece
parthenios@arch.tuc.gr, tandroulaki@isc.tuc.gr
[2] Ephorate of Antiquities of Chania, Hellenic Ministry of Culture and Sports, Chania Crete, Greece

Abstract. In the last decades digital technologies have been employed in the field of cultural heritage for various purposes. Immersive visualization, digital reconstruction of archaeological sites and findings and virtual reality applications are only a few potential tools available when studying the past. The aim of this paper is to present the digital reconstruction of an archaic column, a research conducted at the Digital Media Lab, Technical University of Crete, in coordination with the Hellenic Ministry of Culture and Sports. The 3D models of five very heavy parts of an archaic column were used for studying and virtually reconstructing the complete column. The column was part of an archaic temple unique in size and in type for the area of Chania, in West Crete, Greece. Structure from Motion technique was applied for the reproduction of high quality and accurate digital models of five sandstone drums. Specifically Agisoft Photoscan software was combined with fast, easy and low cost equipment. Furthermore our research team is currently investigating ways to utilize immersive reality for the reconstruction of the archaic column. The five 3D models that were produced with the SfM, are being uploaded as .obj files into Google Tilt Brush. Subsequently the user can experiment by moving, rotating and scaling the individual 3D parts in a 3D environment in real time, in Vive HTC, thus drastically simplifying the digital reconstruction process for similar projects. Finally, a hypothetical façade and a plan view of a similar archaic temple were transcribed in opaque sketches and imported in the immersive reality environment in order to serve as the canvas on which the 3D reconstruction of the column can take place in real scale.

Keywords: Cultural heritage · Structure from motion · Virtual reconstruction · Immersive reality

1 Introduction

This paper aims to present our research realized in Digital Media Lab, Technical University of Crete, supported by the Hellenic Ministry of Culture and Sports, via Ephorate of Antiquities of Chania. Using Structure from Motion Techniques, 3D models of five very heavy parts of an archaic column were produced. The five drums of the column were found in 1997, in a salvage excavation in the town of Chania, in West Crete, Greece. The archaeologists believe that they were parts of an archaic temple

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unique in size and in type for the area. Nowadays the five drums are exposed, in random place in the yard of Archaeological Museum of Chania (Fig. 1) but soon they are going to be moved and reconstructed as column at the New Archaeological Museum. The items are extremely heavy so the experiment for their manipulation in a 3D environment, could be useful for the curators to find their original place. Agisoft Photoscan software produced the accurate 3D models of the items and the .obj files were imported in 3dsMax software where the drums were scaled and placed the one up to the other, until the complete column was created. Meanwhile the reconstruction of the column could be done in 3D environment, in Vive HTC by using the Google Tilt Brush in which the imported .obj files of the five drums could been moved, rotated or scaled.

Fig. 1. The five drums of the archaic column exposed in the yard of the Archaeological Museum of Chania, in West Crete, Greece.

2 3D Modeling in Cultural Heritage

Nowadays, new digital technologies for archaeological research are applied for recording, presenting and promoting famous or unknown archaeological sites, monuments and findings (Cosmas et al. 2001). The 3D visualization can be done with very expensive and specialized equipment such as laser scanners but also by photogrammetric methods i.e. using non metric digital cameras and 3d modeling and rendering software (El-Hakim 2002). The use of three-dimensional models of Cultural Heritage is useful in mapping archaeological sites, monuments and objects or for archival and scientific purposes. Digital models can be used in studies for conservation status, for damage recording or mapping the initial state of the monuments before the begging of restoration (Scopigno et al. 2011).

3 Virtual Reality and Cultural Heritage

Virtual Reality (VR) technologies are going to have a significant influence in life and will bring changes in our future work in archaeological field. Computer technologies in VR field, use software to generate realistic images, sounds and interactions that reproduce a real environment, and simulate a user's physical presence in this environment. Moreover, VR fulfils the creation of realistic and immersive simulation of a three-dimensional environment, using interactive software and hardware, and experienced or controlled by movement of the user´s body or as an immersive, interactive experience generated by a computer. Furthermore in archaeological sciences, VR offers a fascinating opportunity to visit monuments in the past or places, which are not easily approachable, often from positions which are not possible in real life (Parthenios et al. 2016).

Using VR it is possible to explore artefacts in a computer-generated environment on a different reality, and to immerse oneself into the past or in a virtual museum without leaving the current real-life situation. For the VR experience, the user should only see the virtual world and he needs to wear a VR headset which fits around the head and over the eyes to visually separate themselves from the physical world. As with any other language, VR will be useful to transmit information over different media. In the precise area of museums: VR will help for the preservation of the heritage thanks to virtual replicas or reuniting disperse remains (reconstruction of objects and monuments linked to their original context) (Pujol 2004).

4 Existing Projects

4.1 Foundation of the Hellenic World

The Foundation of the Hellenic World (FHW), based in Greece, is a non-profit cultural heritage institution. The goal of the Foundation is to bring together archaeologists, historians, computer scientists, and artists in order to visualize their ideas and utilize the highest level of technology and resources for research and education within the context of Hellenic cultural heritage. To this purpose FHW has established two immersive VR systems. Some of the main projects undertaken by the VR team at FHW include: (i) the reconstruction and virtual journey through the ancient city of Miletus by the coast, (ii) A view of the Temple of Zeus at Olympia in virtual reality, (iii) The famous statue of Zeus at Olympia as seen through the doors of the temple of Asia Minor, (iv) the Temple of Zeus at Olympia, (v) a series of interactive educational environments that bring to life the magical world of Hellenic costume, and more. (Roussou 2001, 2014).

4.2 The Selimiye Mosque of Erdine, Turkey

The project of the Selimiye Mosque of Erdine, Turkey was carried out by the co-operation between BİMTAŞ, a company of the Greater Municipality of Instanbul, and the Photogrammetry & Laser Scanning Lab of the HafenCity University Hanburg, Germany. The virtual 3D model of the mosque is used for the demonstration of an immersive and interactive visualisation using the new VR system HTC Vive (Kersten 2017).

5 The Greek Doric Order

Ancient Greek architecture is best known from its temples which were divided in three defined orders: the Doric, the Ionic, and the Corinthian Order (Fig. 2). The Greek ancient temples were the most important and most extensive building type in ancient Greek architecture. Mainly the structures were built to house deity statues of ancient Greek religion and frequently the interior of the temples were used to store votive offerings.

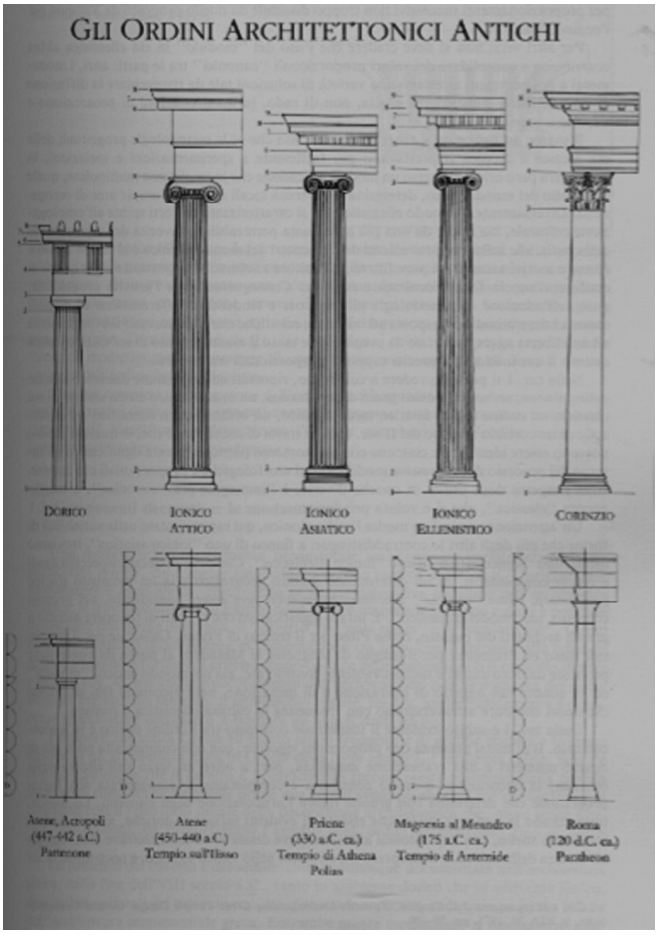


Fig. 2. Sketch of the three ancient architect orders, the Doric, the Ionic, and the Corinthian Order. Giorgio Rocco, « Guida alla Lettura degli Ordini Architettonici Antichi, I.Il Dorico » , Tav.I (Rocco 1994)

The Doric Order (Fig. 3) was the first style of Classical Architecture, which is the sophisticated architectural styles of ancient Greece and Rome that set the standards for beauty, harmony, and strength for European architecture. It was the earliest of the three orders of Greek and later Roman of stone temple architecture, it became popular in Archaic period, roughly 750–480 BCE and replaced the previous style of basic, wood structures. It is most easily recognized by two basic features: the columns and the entablature. The purpose of the columns was to support the weight of the ceiling and in Doric order the column shaft is simple and tapered, meaning it is wider at the base than

the top. The Doric columns, in their original Greek version, stood directly on the flat pavement of the temple without a base, called the stylobate. The top of the column has a wide flat section called the capital and its role was to support directly the weight of the ceiling. Capitals in Doric Order are smooth, without decoration and are flared, meaning the top is wider than the base. It was the earliest and in its essence the simplest of the orders, though still with complex details in the entablature above. With a height only four to eight times their diameter, the columns were the most flat of all the classical orders; their drums were divided in 20 stripes; and they were topped by a smooth capital that flared from the column to meet a square abacus at the intersection with the horizontal beam (architrave) that they carried (Lippolis et al. 2007).

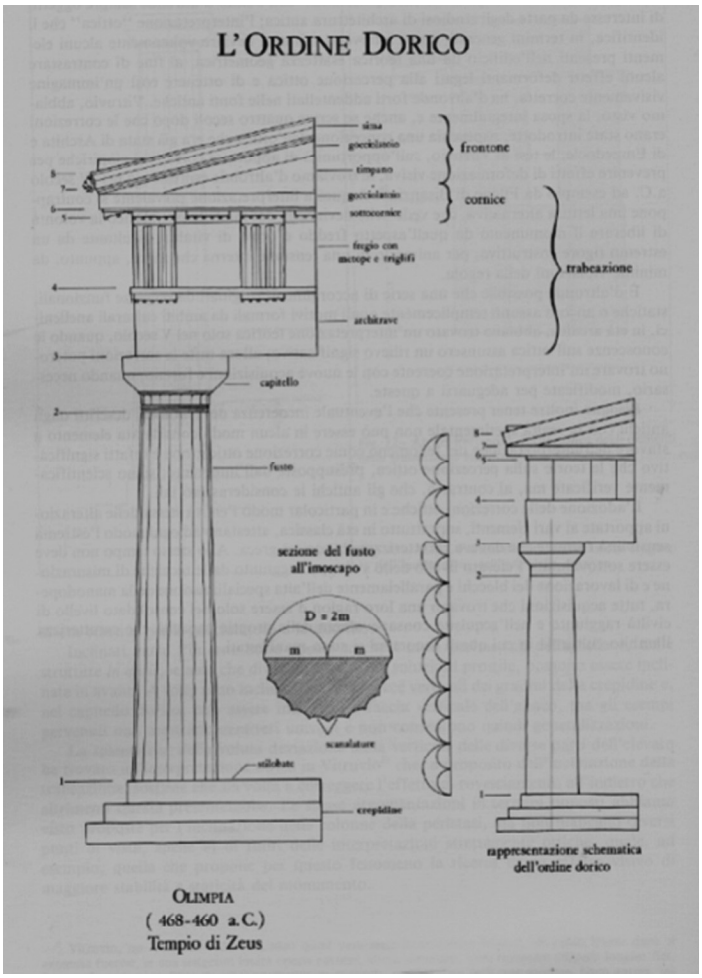


Fig. 3. Sketch of Doric Order, the earliest of the three orders of Greek and later Roman architecture. Giorgio Rocco, « Guida alla Lettura degli Ordini Architettonici Antichi, I.Il Dorico » , Tav.V (Rocco 1994)

6 Digital Reconstruction of an Archaic Column from Five Drums

In 1997 in a rescue excavation, in the centre of the city of Chania, at Michelidakis street and on the Raisakis-Benakis plot were revealed five striped drums of sandstone, placed in the ground in random place (Fig. 4) The five drums have similar dimensions, their height is about 0,8 m and their diameter are about similar and range 0,80–0,90 m (Table 1). According to the archaeologist of the excavation, Mrs St. Markoulaki, the progressive decrease observed in the diameter of the drums indicates that they belong to the same column. After the excavation, the drums were transferred for safekeeping and exposure to the garden of the Archaeological Museum of Chania and were placed in a random place on the ground (Fig. 1).

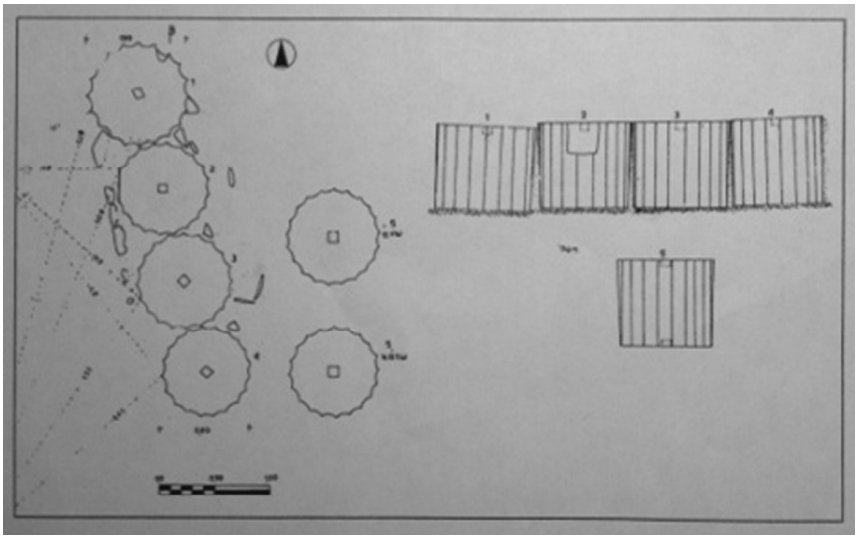


Fig. 4. The five drums were found in second use, in a salvage excavation in the centre of Chania, in Crete, Greece. (Drawing: Ephorate of Antiquities of Chania, Hellenic Ministry of Culture and Sports.)

Nowadays the exhibition of the New Archaeological Museum of Chania is being prepared and the archaeologists are planning to expose the archaic column in reconstruction. The items are very heavy so it is not easy to move them and try to find their original position. The research digitally via the five 3D models of the drums and as a result the digital reconstruction of the column would be valuable and helpful (Parthenios 2017).

The modelling of the drums was done using a photogrammetric Structure from Motion Techniques. Several factors influenced the quality of the models, such as position of the items, accessibility, lighting conditions on all surfaces, size and weight.

For the creation of digital models, the five drums were photographed with two different cameras, Nikon Coolpix P530 and Canon EOS 700D (Fig. 6), following the CIPA 3 × 3 guidelines and rules (Waldhäusl et al. 1994).

Table 1. The dimensions of the five stripped archaic drums

Drum	Dimensions		Stripes
	Diameter	Height	
S1	77 cm	77 cm	17
S2	78 cm	76 cm	20
S3	78 cm	78 cm	20
S4	77,5 cm	78 cm	20
S5	88 cm	75,5 cm	20

It was important to arrange the cameras settings with proper focal length and shutter speed. Some targets were placed around the items to arrange the dimensions (Fig. 5). Cloudy hours were selected, during the process of image recording to avoid shadows on the items. Initially a tripod was used, but most of the images captured without it because there was no space to put it around the drums.

Fig. 5. Targets were placed around the drum S1 during the capturing process.

After photo shooting the appropriate images were selected and the process of the three-dimensional models' production began. The photos, in portrait and in landscape mode, were imported into the Agisoft Photoscan software and the modelling process began (Figs. 7a, b).

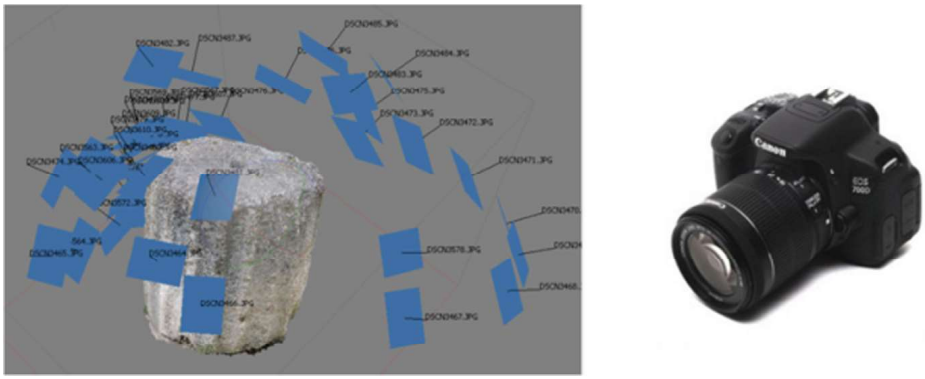
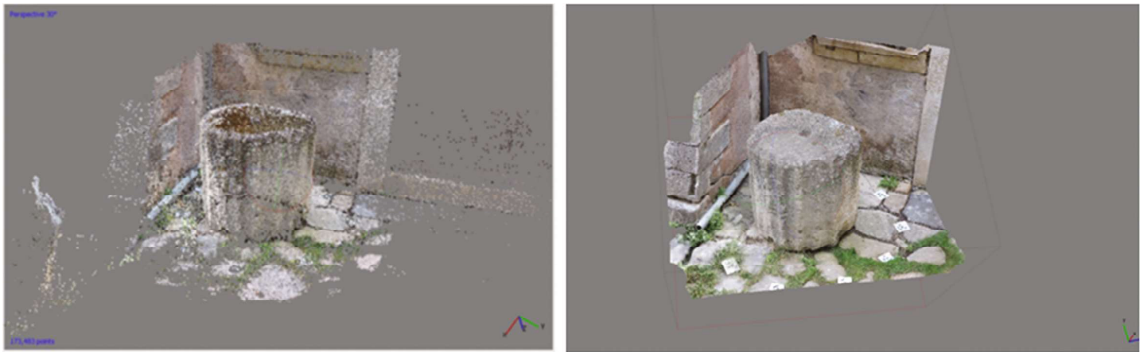


Fig. 6. The images of the drum S1 and the digital camera used for the 3D modeling.



(a) (b)

Fig. 7. The point cloud and the tiled model of the S1 drum produced in Agisoft Photoscan software.

The sets of images (Fig. 6) used were different for each drum and the process needed a long time, depending on the number of photos used in each model. A number of 3D models were created for each drum (Fig. 8). After carefully comparing them we selected the most appropriate for the next phase of the digital reconstruction of the column.

The cameras used for the modelling of the drums in Agisoft Photoscan, in total were: 42 for drum S1, 28 for S2, 38 for S3, 33 for S4 and 37 for S5.

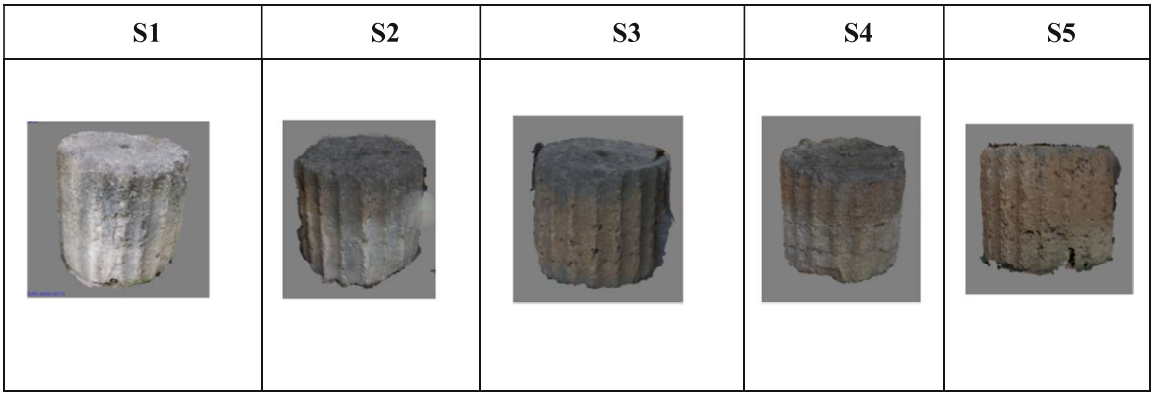
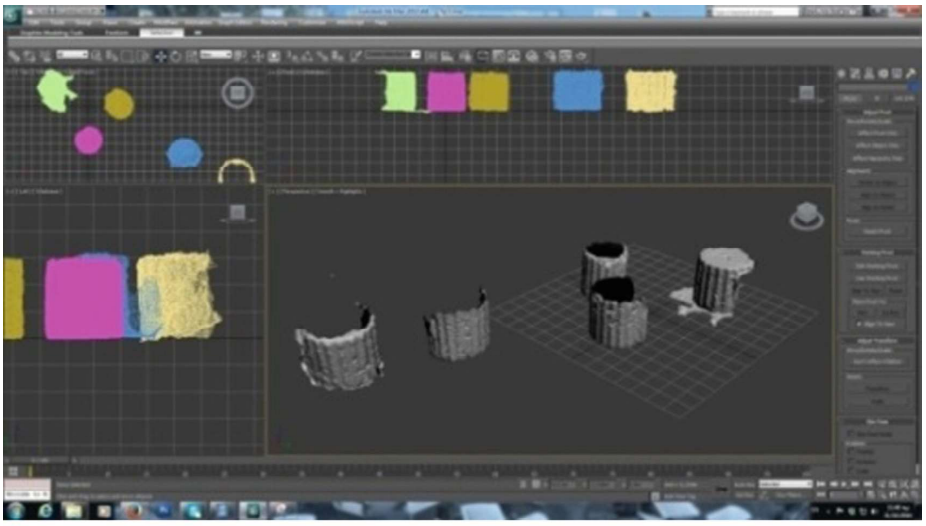
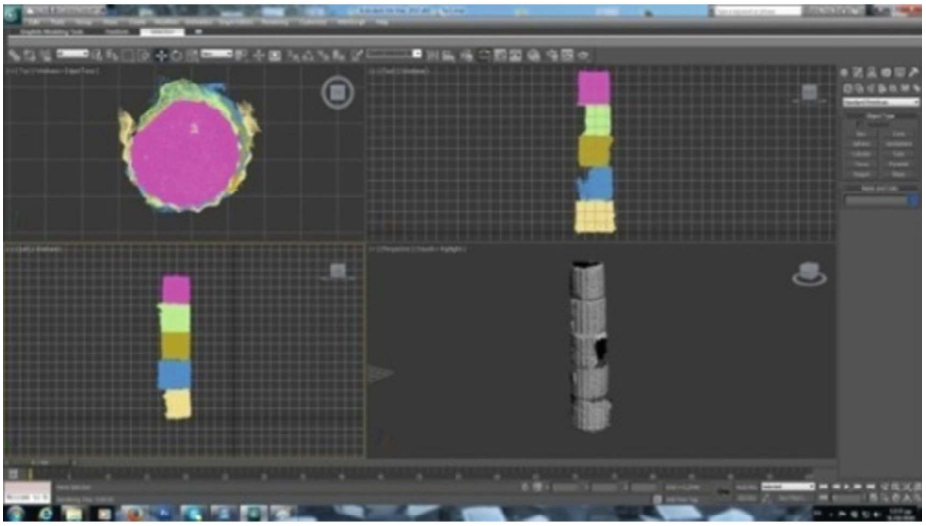


Fig. 8. The accurate 3D models of the five drums of the archaic column.

Afterwards used Autodesk 3ds Max in order to reconstruct the column. The five obj files, derived from Agisoft Photoscan, were imported into 3ds Max (Figs. 9a, b). Each drum was manually scaled and aligned. The composition was made manually and the position of each drum was chosen according to the perimeter dimensions at the upper and lower sides. First, S5 was placed, followed by S3, S4, S2 and S1 (Figs. 9a, b). Also, the direction and width of the ribs helped. Deterioration of the surfaces did not help because there was a loss of material mainly due to mechanical erosion.



(a)



(b)

Fig. 9. The digital reconstruction of the column using the 3D models of five drums in the 3ds Max software.

Moreover a second experimental path was chosen in addition to the first one in order to test the digital reconstruction of the column. We used HTC Vive along with Tilt Brush software. We took advantage of the software's ability to import 3D geometry (the five .obj files of the drums) and then manipulate each object separately in an immersive 3D environment. We were able to easily grab, move, rotate and finally place each drum on top of the other using the two HTC Vive Controllers (Fig. 10). This offered us the ability to quickly test possible placements for each drum. Furthermore, we were able to sketch in 3D on top of the virtual drums, notating and high lighting points for further research.

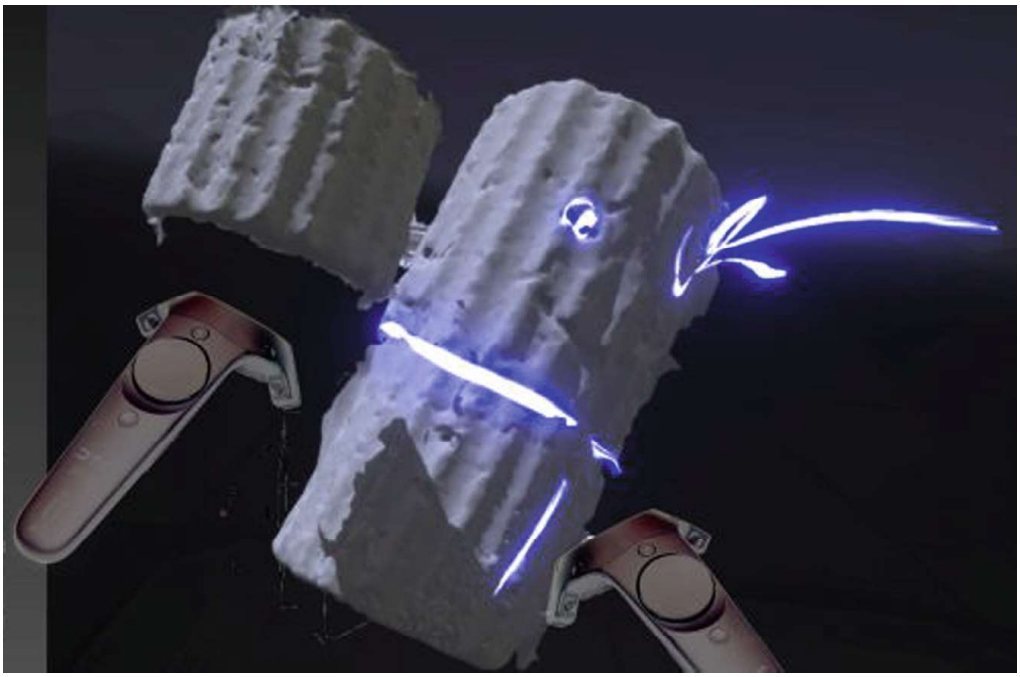
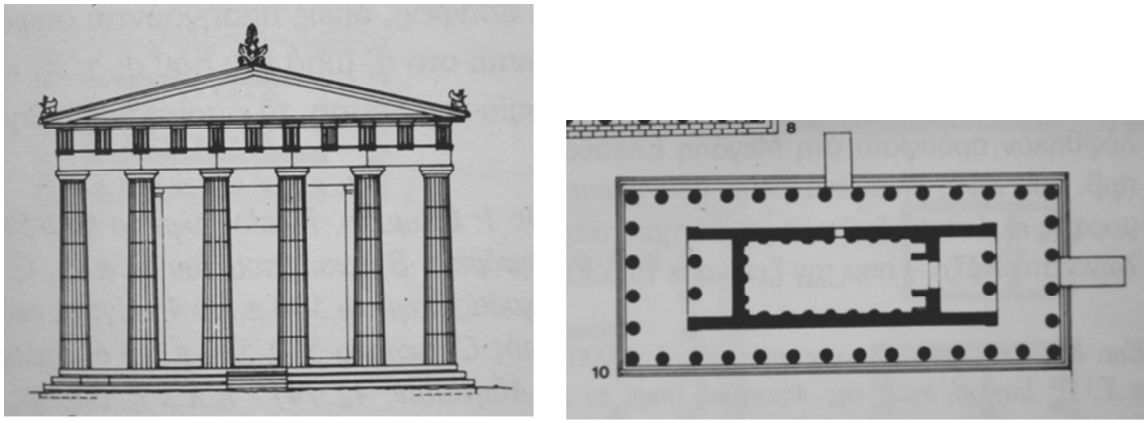


Fig. 10. Using Tilt Brush and HTC Vive for the digital reconstruction of the archaic column from five drums.

7 A Hypothetical Reconstruction of an Archaic Temple

The five sandstone drums were found in 1997, in an excavation by the Greek Ministry of Culture. They were found on the ground, in second use and according to the archaeologist of the excavation, the progressive decrease observed in the diameter of the drums indicates that they belong to the same column. So far there are no more information about the real type, size or location of the ancient construction in which the column belonged. But the type, the form and the dating (c.a. 560 B.C.) of the drums indicate that the column could be part of an ancient temple of Doric order form.



(a) **(b)**

Fig. 11. The drawings of the temple of Athena Alea at Tegea, Peloponnese. The façade and the plan, of the temple used for the creation of the virtual reconstruction. « Griechisches Bauwesen in der Antike » , Wolfang Müller- Wiener, Fig. 82, p.153 (Müller-Wiener 1988).

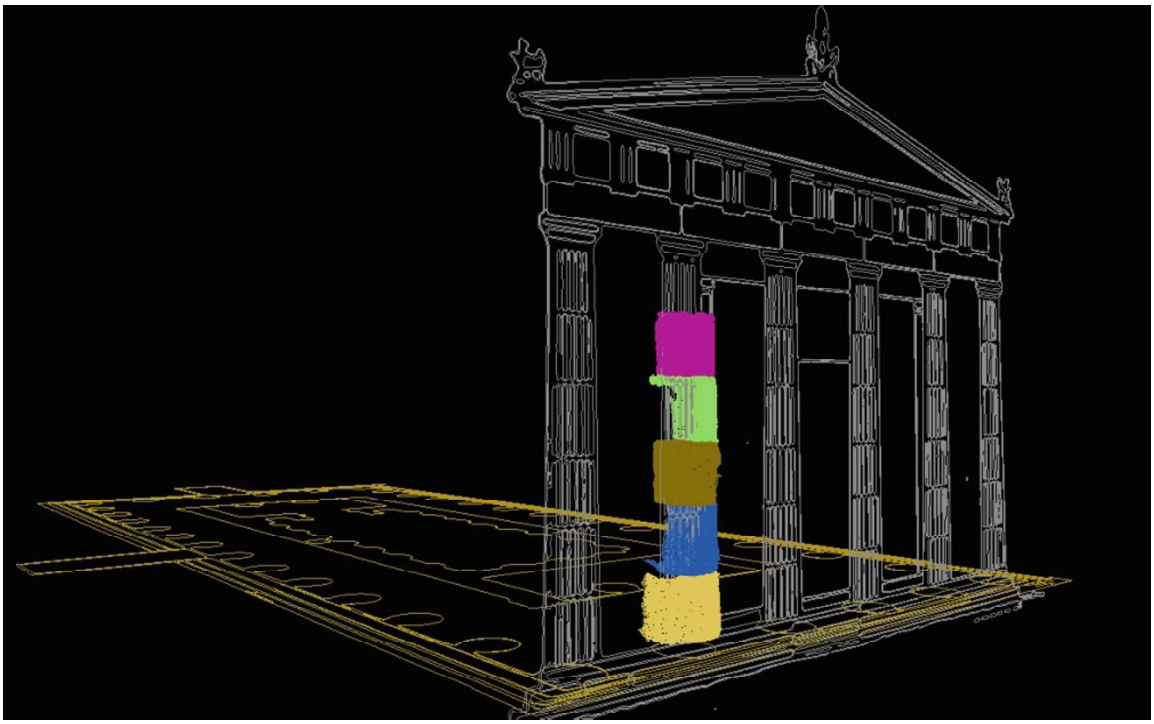


Fig. 12. The façade and the plan view drawings of the Temple of Athena Alea in Tegea, Peloponnese, (traced using Power Trace in Corel Draw) serve as a 3D canvas on which the five drums (modeled in Agisoft Photoscan) are being reconstructed into a column.

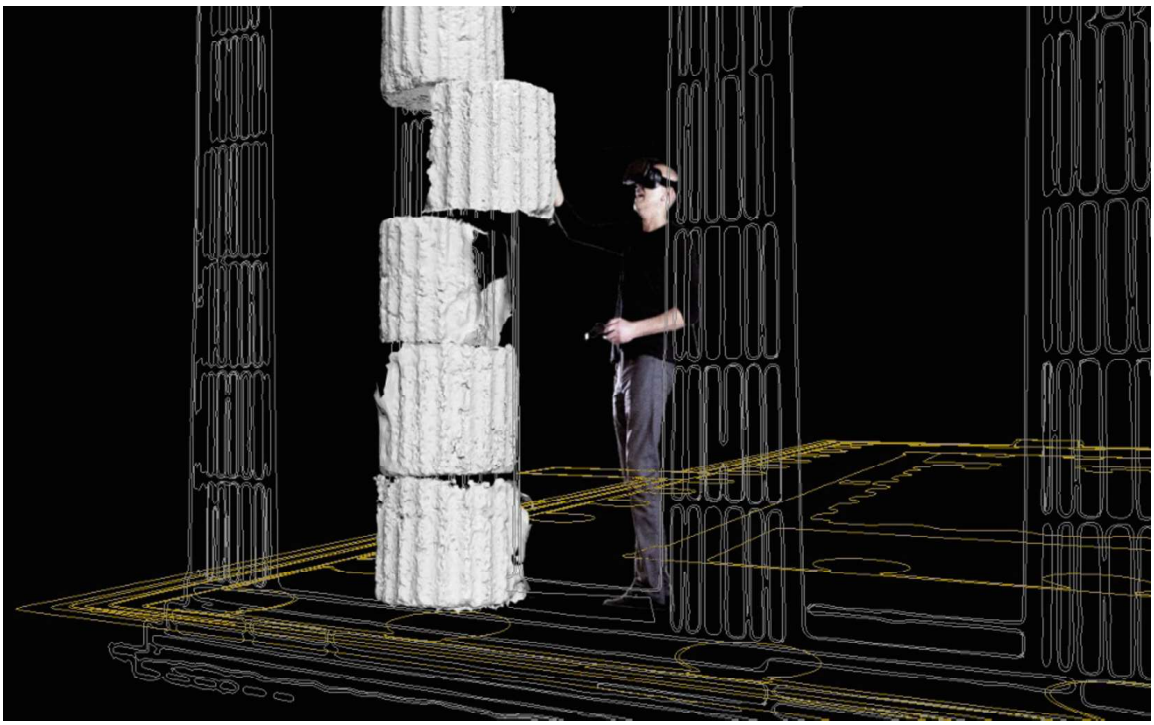


Fig. 13. In a 3D environment the user with the Google Tilt Brush can experiment by moving, rotating, scaling and placing the drums on the column.

Using the drawings of a typical Doric Temple (Figs. 11a, b), as documented by Wolfang Müller- Wiener, on « Griechisches Bauwesen in der Antike », Fig. 82, p.153, we experimented with creating a 3D canvas inside the immersive environment on which the 3D reconstruction of the column can take place in real scale. The black and white façade and plan view drawings of the Temple of Athena Alea in Tegea, Peloponnese, created by Wolfang Müller- Wiener, in « Griechisches Bauwesen in der Antike » where traced using Power Trace in Corel Draw (Fig. 12), in order to be converted from scanned images to vectors. The vectors were exported to .dwg files, then imported to 3ds Max and saved as .obj files, which ultimately were imported in Google Tilt Brush in order to serve as the 3D canvas where the user (Fig. 13) can experiment by moving, rotating, scaling and placing the drums on the column.

8 Conclusions

Experimenting with recently commercially available immersive reality applications has the potential of revealing valuable new tools in the field of virtual reconstruction in cultural heritage. Our research demonstrates how simple to use tools can be combined in order to create a virtual reconstruction of an archaic column from its five spare drums, inside a hypothetical 3D environment where the user can interact with the artifacts in real scale and in real time. Future research should focus on improving scaling accuracy of the imported .obj 3D models in the Google Tilt Brush environment.

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