

A Petrified Petrifying Eyesight: A Story for the MEDUSA'S HEADS from Istanbul, Turkey

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The Basilica Cistern, *Yerebatan Sarnici* in Turkish, is the largest of all the hundreds of ancient cisterns that rise below the city of Istanbul. In the North-West corner of the cistern, the bases of two columns reuse the carved blocks with the face of Medusa. The origin of the two heads is unknown; it is possible to say the same for a third (double) head located in the Archaeological Museum of Istanbul. These three/four heads of Medusa are masterpieces from the late Roman art. The research presented here starts from a digital photogrammetric study of this set of Medusa's heads, this allowed to obtain a 3D digital model to study its morphology and shapes, then the model has been collocated inside the 3D virtual reconstruction of the cistern to have an overall view. The assumption formulated here, with the cross referencing obtained during the research phase and digital photogrammetry, lead us to the idea that the heads may come from a Doric temple dedicated to Athena, in this specific case used as a metope, or from the triumphal arch dedicated to Constantine in Constantinople. The aim is therefore to bring back to life, using a process of virtual reconstruction, with contemporary technology, such as virtual reality, an architectural element from the past, through a virtual journey that traces the history of these stone giants, placing them in their hypothetical original context with augmented reality.

Key words:

Photogrammetry, Virtual Reality, Istanbul, Medusa, Sculpture

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INTRODUCTION

Working as scholars in the fields of built and Cultural Heritage, it is possible to see many interesting elements in complex historical context, it may happen often to meet the beauty of architecture parts and complex or fall in the fascination coming from the ruins [Macaulay 1953]. For a long time in the past, interacting with these influences meant to make drawings in place, operating measurements, taking pictures, creating a mix of different media describing the item seen somewhere; a long work most of the time made with accuracy and dedication. In the very recent years, the progressive and from a point rapid evolution of photogrammetry has gifted all the people involved in such operations with a great tool: the possibility to create good or even excellent fully textured 3D models out of a set of pictures taken with proper quality and strategy. The digital transformation of photogrammetry brought an extreme simplification, moving the complexity of the workflow from the need of proper hardware, preprocessing and long procedures to the need about taking correct pictures and then applying proper processing accordingly to the final use intended in the research. These specific operations are not easily recognizable in place: any person taking pictures around a piece of the patrimony may be at work for the production of a 3D model [Pucci 2013] and indirectly, any picture taken (i.e. by tourists) and shared on the internet may be used for the creation of a 3D model [Samer et al. 2011]. Then it is clear how much these innovations influenced the production of 3D models and their dissemination around the web, the academia, the conferences, in papers and books. The proper use of these tools allows to "bring home" (or to the laboratory) a good quality 3D model, fully exploiting the properties of the camera

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in use and the condition created by a procedure highly compliant with Cultural Heritage projects. The combination of these specific models with virtual reality environment completes well the intention of sharing and presenting items in their environment as well as in their hypothetic reconstruction. The immersive experience is not only “spectacular” or useful for learning/teaching purposes, it is also a good occasion to check and verify proportions, impressions, perceptions in an environment coming from a reconstruction or sited far away. Very interesting pieces like the “Medusa’s Heads” from Istanbul and their “hidden stories” are a great subject of investigation, especially using multiple tentative in defining the original architecture to which they belonged. Knowing the limit due to the impossibility about solving out of all the doubts on their real use/destination, but defining solutions that (even if just on the base of a process of exclusion) may contribute to a better knowledge about these impressive findings.

THE “CISTERNA BASILICA”

The Basilica Cistern is part of one of the most special and symbolic categories of buildings in Istanbul: the underground ones. Built in 532 AD by Justinian to regulate the water supply of Constantinople, it has the dimensions of a large cathedral: 138 x 65 meters, it can contain 80.000 cubic meters of water [Önlü 2010]. The ceiling is supported by 336 marble columns, two of which are held by two protomes representing Gorgons (Fig.1). The cistern takes its name from the fact that it was built under a large public square on the first hill of Constantinople, the *Stoa Basilica*, a great *Stoa* built about the 3rd-4th century during the early Roman age. It was meant to be the centre of commerce and a cultural hub, and then it was destroyed by a fire in 476 AD. After the Ottoman conquest of Constantinople, the Ottomans used the water of the cistern to irrigate the gardens of the Topkapi Palace. After installing their relatively modern water system, however, the Ottomans stopped using the water of the cistern [Mango 1978]. Forgotten by the city authorities, it was not discovered until 1545, when the French scientist Petrus Gyllius was researching Byzantine antiquities in the city. He was looking for remains of the *Stoa Basilica*, and when local inhabitants told him they were able to get water lowering the buckets into a pit below their basement levels, he had a great indication. The Basilica Cistern has undergone several restorations since its foundation. During the 1985 restoration, 50.000 tons of sludge were removed from tanks, and platforms built all over to replace the boats once used to visit the cistern. The cistern opened to the public in its current condition on nine September 1987 [Barsanti 1990].

MYTHS, FRAGMENTS AND BUILDING BEHAVIOURS

The heads of Medusa in the Istanbul cistern are clearly fragments coming from a previous building, probably elements for an arch or from a frieze. Their re-use as basements of columns is clearly done for some practical choice: two large, well usable blocks, no matter if they are sculpted or not, recognized by the workers of the cistern as excellent parts for various building necessities. They may be parts of some ruined architecture (maybe the Constantine’s Gate, but it is a hypothesis impossible to verify), or something never completed (and then coming from a courtyard, as it may suggest the similar block with the heads 3 and 4, still belonging to a single stone block, which sculpting was interrupted before the separation in two parts). This block is preserved in the Istanbul Archaeological Museum and shows similar size, features and sculpture style of the protomes in the cistern. So, even if these stones are depicting a myth capable to petrify an enemy, and for this reason being an excellent symbol to put like a “shield” on the entrance of a gate, their destiny was being used to support columns, placed underwater, with these interesting faces turned on one side or completely upside down. Such a result is not clearly done with an “architectural” choice, it is somehow a vernacular approach to these pieces, and it is a specific practical behaviour, a re-use of a stone that may be sculpted, but first of all it is a “usable” stone for its material quality, not really for its artistic or heritage values. The choice about turning them on one side or the other was probably guided by the condition of the piece or by its workability.

Overall, centuries later after this construction choice, the discovery of such pieces was quite precious: inside the beauty of the enormous space of the cistern, two weird elements from a distant past, hidden in the depth of the subterranean architecture, ready to capture the attention and the curiosity of many scholars and tourists. These heads have a great symbolic and evocative value: they open a window into an older past inside the ancient cistern, they show the presence/end of myths in that society and link them to the classic age, they bring to the public the fierce strength of the Medusa’s legend in a deep part of an underground building, entering the scene at the end of the visit and communicating something like “I have a story to tell”, but this is done by stone lips, capable to suggest nothing more than an impression.

In the will of investigating and develop graphic and “architectonic” hypothesis about these parts, from 2014 a personal research project started developing its structure. The project has foreseen four sessions: the 3D digitalization of all the usable elements connected to the protomes in the cistern to better understand shape and size of these parts; the definition of the state of knowledge about these elements and the myth of the Gorgons; the developing of virtual reconstructive hypothesis, the development of presentation and communication solutions based on Virtual/Augmented realities tools suitable for sharing, and transferring information about the “Medusa’s heads” and their architectures.

To bring on these operations the choice was using photogrammetry because of its easy operational conditions, simplicity in the transport abroad of all the needed tools, excellent maneuverability in any conditions. The production of digital 3D models for real time visualization was the aim of the following modeling. Thus, the models were also optimized to produce a 3D printed version of the protomes. A better understanding and control of the shape and hypothesis development about the use of these elements was possible thank to these physical models

For the virtual/augmented realities it was preferred to optimize the 3D models in two different solutions, one oriented to “on-site” presentation, with a structure based on the use of an *Oculus Rift*¹ viewer and a virtual environment developed in *Unreal Engine*²; the other oriented to “on-line” presentation, with a structure based on common display and/or personal devices, optionally used inside cardboard/cardboard-like viewers.

PHOTOGRAMMETRY OF THE HEADS ONE AND TWO

The photogrammetry of the heads 1 and 2 was the most complex and difficult of the series. The shooting was done operating freely during a visit to the cistern, acting like tourists, gathering the data accordingly to a very preliminary documentation plan. At the time of this first survey (2014) obviously the two heads were well known, but no digital survey was available, nor detailed drawings, nor complete images of all the sides of each element. Most of the pictures online were taken by tourists and showing almost the same side and/or point of view. The low lighting in the space of the cistern sometimes caused the picture to have micro-blurred issues, often in the pictures could be seen the use of flash lighting. These conditions produced the need to go in place for taking directly the pictures, with no options about using some crowd sourcing operation for gather picture sets to be used for photogrammetry reconstructions, like those well experimented in the past by the research group from the “Dipartimento di Architettura” (DIDA) University of Florence [Mancuso and Pasquali 2015] and accurately explored by other scholars [Grün et al. 2004]. To produce a well working set of images, the camera in use was a Nikon D800e digital SLR with a 36.3 Megapixel unfiltered sensor. A camera capable to get high resolution images keeping a low level of noise even in high ISO settings, a proper condition for the low light of the cistern. After some evaluations, the lens used for the two photographic sets was a Sigma Zoom 12-24 mm F4.5 set on 20 mm stopped down at its full opening: F4.5. The choice of a significant wide-angle lens was due to more than one aspect: with a wide angle lens the risk of micro-blurred images at low shutter speeds is reduced; the strong perspective may be useful in the photogrammetry process; the wide field allows to work easily in the quite narrow space around the heads and avoiding the tourists walking around. The camera sensor was set at ISO 6400, in this way the shutter was operated at a speed about 1/3 and 1/8 accordingly to the lighting conditions. All the shots were taken with the camera handheld, so there was the need for a certain skill in keeping a stable position and avoiding any significant shaking while shooting (Figs. 2 and 3). The head with the face of Medusa turned upside down, named “number 1”, was covered with 135 shots, from these a sub-selection of 109 produced the photogrammetry. The head with the face of Medusa turned one its right side, named “number 2”, was covered with 60 shots, from these a sub-selection of 40 produced the photogrammetry. The logic of sub-selection was connected to the presence of shaking-blur, shadows from visitors and lights from their cameras.

PHOTOGRAMMETRY OF THE HEADS THREE AND FOUR

The heads 3 and 4 brought no particular difficulties if not those connected to the larger size of the block (with some minor problem in getting elements from the top part of the stone. The block has quite raw characteristics: only the protomes are well defined and clearly similar to those from the cistern. This condition of partially completed

¹ www.oculus.com

² <http://www.unrealengine.com>

element, seems to support the theory about an ongoing artefact, something never completed, maybe belonging to a set of many other parts disseminated around the city. So wrong, one of the faces is largely lost, only part of the chin, the lips, the lower part of the hair and parts of the cheeks remained (Fig. 4). During the survey at the Istanbul Archaeological Museum, the operators reached the courtyard of the museum on a cloudy day of July 2017, an ideal weather for taking photogrammetry pictures in open spaces. The camera in use was the same of the 2014, with the use of a 24-120 mm F4 Nikkor Zoom lens, used at 24 mm. Most of the shots were taken with the camera handheld, with an ISO setting of 160 and the diaphragm set at F8, obtaining a shutter speed of about 1/180, quite good for capturing correct stable images and a proper depth of field, keeping the stone in full focus and blurring the background. The overall number of shots was 192, all taken in NEF raw format.

PHOTOGRAMMETRY AND POST PROCESSING

The following processing was developed in five main steps: 1) checking and selecting and/or editing the images, with the pre-processing of the RAW file and the extraction of optimized JPG files. 2) generation of 3D models using *Agisoft Photoscan*³, using a classic processing starting from the alignment, the creation of a dense cloud followed by the generation of the mesh (done at the maximum number of triangles) and in the end the creation of the texture. 3) post processing of the resulting model in *Raindrop Geomagic Studio*⁴, with the refining of the polygonal mesh, its decimation to a lighter model, keeping almost all the details of the protomes (Fig. 5) then these bases were used to develop the “Virtual Reality” (VR) environment 4) development of specific reconstructions about all the main hypothesis on the original positioning of the heads. This was done with classic modelling procedures in *Maxon Cinema 4D*⁵ and then exporting the results into the *Sketchfab.com*⁶ platform. This part was not only useful for displaying, but quite valuable for appreciating the architectural result and the complexity of the composition, and, finally, the “realism” of the result in front of the pure abstraction. 5) Development and assessment of the VR environment, with the space of the cistern reconstructed to link together all the products of this research, offering the virtual space of the cistern with a full connection to the state of knowledge about the Medusa’s heads.

VIRTUAL RECONSTRUCTION

Using the Agisoft Photoscan software it was possible to have proper bases to analyse and study the shapes of the four protomes, their peculiarity, comparing the dimensions, trying to find a common thread that could lead to put them in their original context and historical period. Just analysing the position of the two protomes inside the Basilica Cistern it is easy to understand that these big pieces of stone no longer have the apotropaic symbolic function of the horrid that drives away the horrid, but takes on a pragmatic character. It is quite evident that in this case the “spolia in se” (the remain, the re-used fragment in itself as an object representing a value from the past) has become “spolia in re” (the remain becomes a part used for practical aims) [Settis 1984]. The three hypotheses formulated for the possible belonging of the four Medusa’s heads are a temple, perhaps dedicated to Athena, given to the mythological link between the two figures [Wilk 2000], realised or to be realised before the deconsecrating of the pagan buildings by Theodosius [Bassett 2015]. The others are the belonging to one of the arches of access to the forum of Constantine (in this case it seems more likely to be the head of the archaeological museum), or the belonging to the Stoa Severiana [Adam 1994]. For what concern the proposal of the belonging to the Arch of Constantine we based our research on archaeological sources such as the writings of Pausanias the Periegeta, (2nd century AD) in which he describes his travels; the *Patria Costantinopolitarum*, also known as *Scriptores Originum Costantinopolitarum* (6th century AD), a collection of Byzantine historical works on the history and monuments of the Byzantine Empire [Freely and Çakmak 2004], inside there is a part focusing on the ancient sculptures of the city, and in these writings the author describes the two marble Medusa heads as belonging to the *Proconneso* that was recognized as a work wanted by Constantine. It is impossible to say if they are the same protomes, but it is certain that Medusa was a mythological pagan figure easily used by Constantine. These heads were just inside the Forum of Constantine, which is also the place where the head now at the Archaeological Museum was found just beneath some houses in 1869. [Barsanti 1992]. In fact, it is hypothesised that this great stone was the keystone of one of the two arches giving access to the Forum (Fig. 6).

³ <http://www.agisoft.com>

⁴ [au.3dsystems.com](http://www.3dsystems.com)

⁵ <https://www.maxon.net/en/>

⁶ <http://www.sketchfab.com>

The references for the reconstruction of the arch were the triumphal arches from the Roman Age, such as the Arch of Constantine in Rome [Kaldellis 2016; Russo 2016].

For the hypothesis of the Stoa, it was a little bit more complicated to find an adequate number of sources to come and support a possible solution, because there is not so much information about the *Stoa Severiana*. The respective places of discovery of both the two protomes in the cistern and the two of the large keystones match the first and last part of the Stoa, the location of the cistern coincides with the beginning of the arcaded road (Fig. 7).

The last hypothesis of re-contextualisation of the ruin is the one of the temples dedicated to Athena, because of the strong connection between the two mythological figures. It could be a temple built or to be realized in the Byzantine period and destroyed during the period of Theodosius. For the proportioning of the temple, the key element was found in the metope, one of the heads was used as metope, the sizing was done following the studies about the proportions conducted by Vitruvius, Vignola and Palladio [Pollione and Migotto 1999; Rykwert 1996] (Fig. 8).

THE ONLINE CONTENT

The software used for the making of the VR is *Unreal Engine*⁷, it is a graphic engine developed by *Epic Games*⁸ software house. The first version of this software was created for *Unreal*, a first-person shooter game and across the years the development continued, adapting the software to the new hardware technologies and bringing it to other platforms. The process following to use the software was to export the models in FBX format from *Maxon Cinema 4D*⁹ and import them in *Unreal Engine*. Then the cistern has been optimized and rebuilt to make the visual performance as smooth as possible. The texture of the materials has been recreated and applied to each single element.

For sharing the models in a VR environment, it was used a different solution, adopting the platform *Sketchfab.com*. It is a 3D models Platform, used to publish, share, and discover 3D, VR and “Augmented Reality” (AR) contents. One of the most interesting parts of this platform is a 3D and VR model viewer that allows users to move freely within the 3D scene using the mouse or Google cardboards or other headsets, creating easy to access and use solutions for general VR experiences. The 3D viewer is immediately functional in the *Sketchfab* website or in its mobile apps and can also be embedded in external websites (Fig. 9).

THE VR EXPLORATION

The aim of virtual reality is to simulate a real environment through electronic technologies, giving to the experienter the impression of being really immersed in that environment. Today the term has also taken on a wider meaning and indicates all those simulations that allow some kind of interaction with this kind of environment, as it happens in example in video games, even when the simulation is not total, but involves only certain senses. Creating a virtual environment is not easy and requires time, research and investments. Videogames have played an important role in the growth of this sector, creating a huge market by acting as a flywheel for technological development. As already mentioned above, the purpose of this work is to virtualise the ruin, in order to create new opportunities and new tools for studying and understanding the built heritage. The software *Unreal Engine* was used again to rebuild the cistern and to offer a format that can be reused in any museum context.

With interactive virtual visits, which is a type of active communication, that is possible to provide for the visitors offering them a picture “as much complete as possible” of the ruin and of the current context in which it is located, creating the possibility to offer personalized learning experience in which they can choose what visualize and which information extract accordingly to their personal interests, with an effective active participation of the users.

With the currently available technologies, the use of interactive virtual visits can take place in many ways. For those who will visit the Basilica Cistern and the Archaeological Museum it is possible to imagine an easy solution using QR codes for accessing the documentation getting a clear idea about the nature of the heads and using the whole set of 3D models, Rendering 360, and VR (Fig. 10).

⁷ <http://www.unrealengine.com/>

⁸ <http://www.epicgames.com>

⁹ <https://www.maxon.net/en/>

CONCLUSIONS

Nothing like a real place, nothing like a real video game... On the way to digital heritage the whole academic world is just experimenting. This is correct, sometimes the research uses "from the shelves" tools, and sometimes it finds interesting innovation. In all the cases the creation of the digital heritage environment makes it easier to share and gather information and knowledge for scholars, students, and pupils.

The creation of a new digital resource from the survey of a valuable cultural heritage element which previously was simply documented by basic pictures, is an innovation, a step forward in enhancing the possibility of digital learning and sharing. In the path to create digital tools for learning and communicating cultural heritage and architecture the scenario seems still open and a lot is in need about being discovered and defined.

Thus, well consolidated practices are ongoing and the presence of easy to access and operate digitalization tools together with high performance services like Sketchfab.com [Verdiani et al. 2018] are giving a great contribution to the global digitalization of heritage. In this vast transformation one of the most strategic aspect is the integration of contents and the interrelationships between a specific model, other models and a proper set of contents.

Such an improvement may work greatly in the development of future approaches between even very different media, bringing together state of the art, hypothesis, and intellectual speculations [Verdiani 2017]. That is what was tried with this research about these Medusa's heads, with this paper as a first resume of the state of development of an intricate puzzle, almost impossible to solution, but for this, fascinating and challenging.

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FIGURES

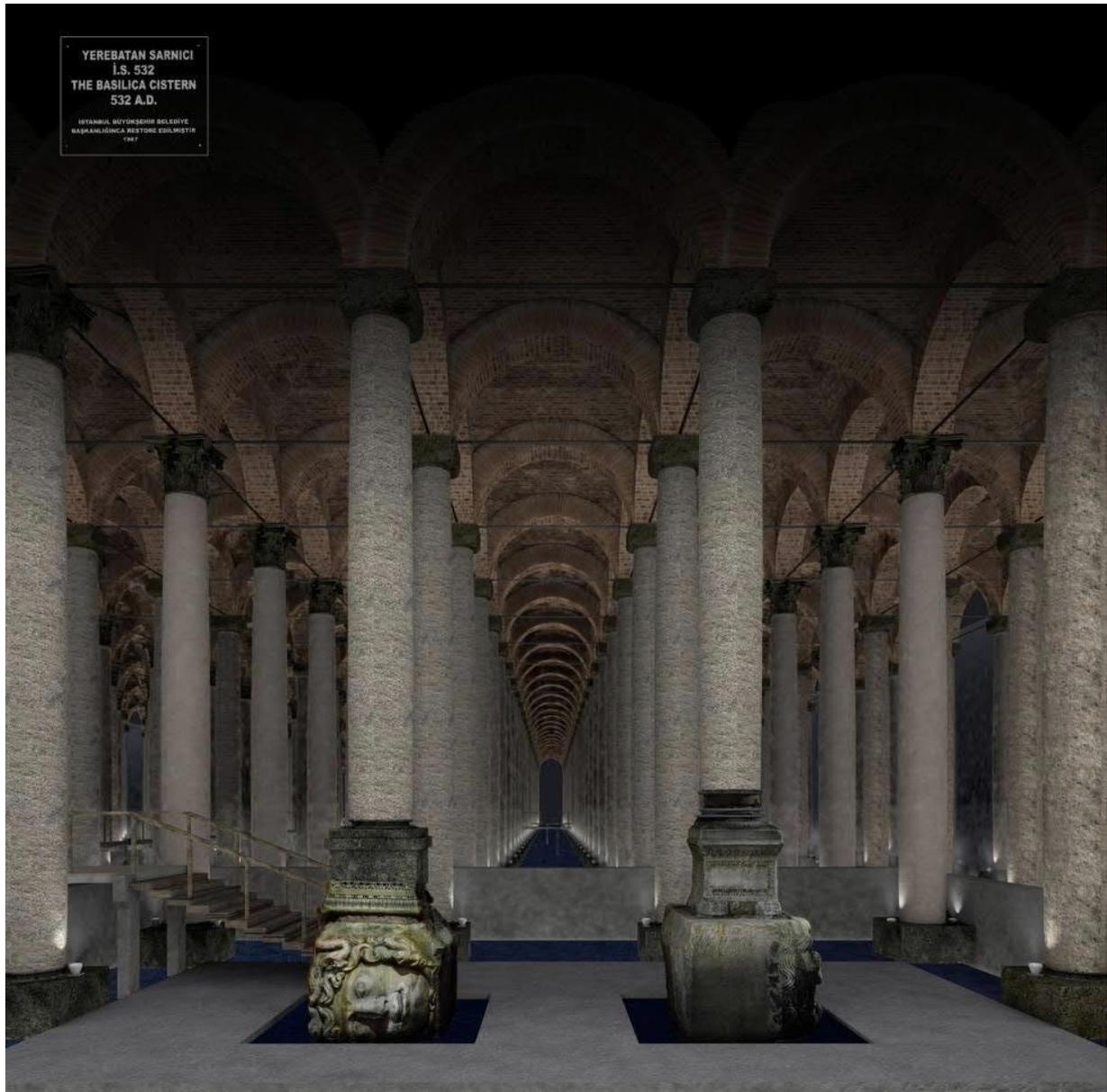


Fig. 1. Rendering of the interior of the Basilica Cistern, Maxon Cinema4D



Fig. 2. Photogrammetry of the head of Medusa number 2, inside the Basilica Cistern, Agisoft Photoscan

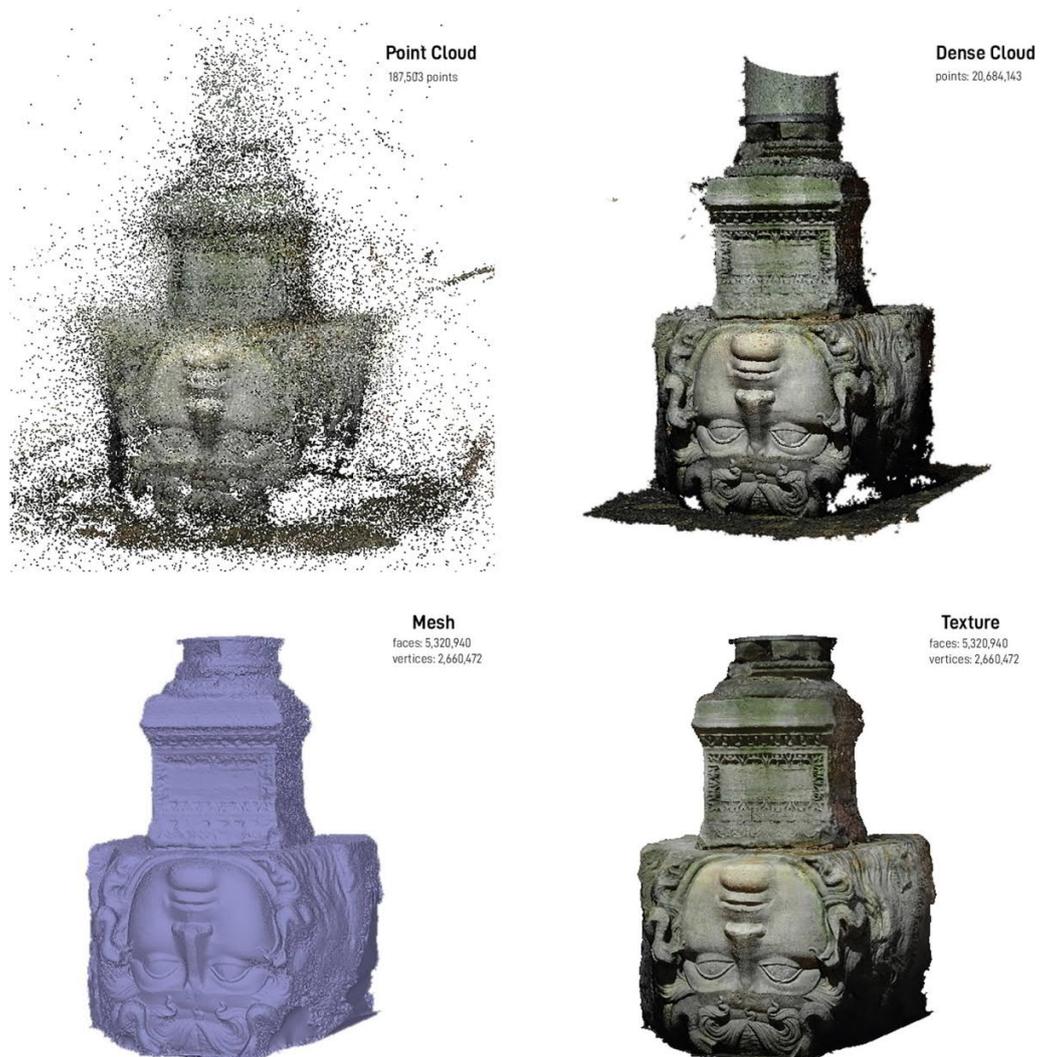


Fig. 3. Photogrammetry of the head of Medusa number one inside the Basilica Cistern, Agisoft Photoscan



Fig. 4. Photogrammetry of the two protomes preserved at the Archeological Museum in Istanbul

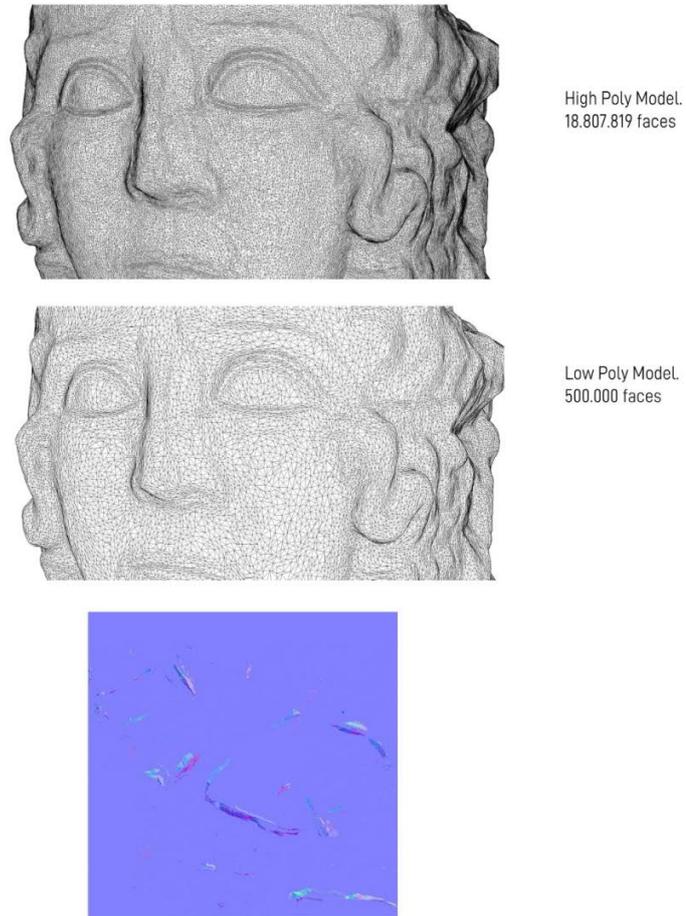


Fig. 5. "Baking" process on the 3D digital model, a series of features are calculated and organized to allow a faster computational performance in the visual rendering phases

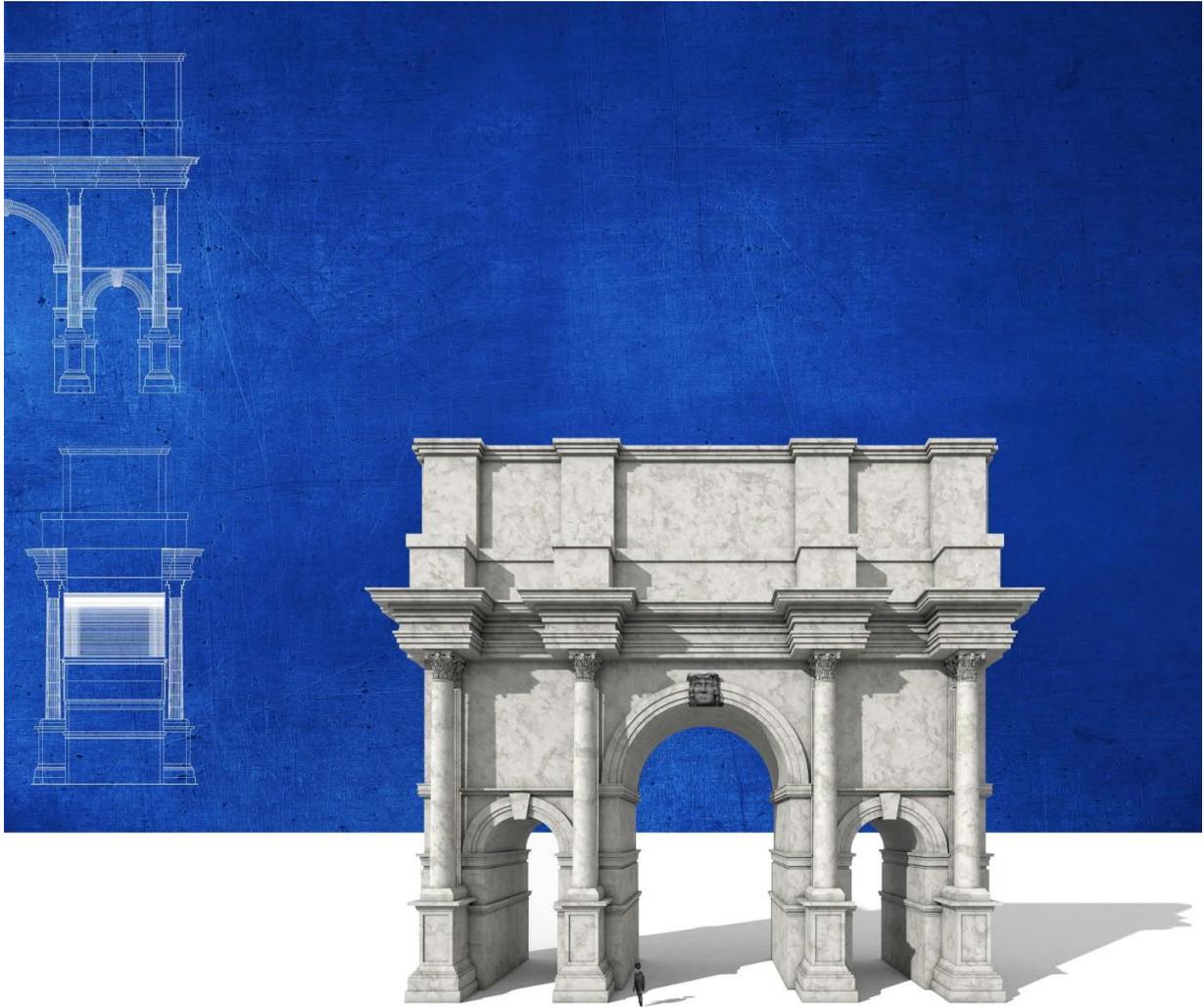


Fig. 6. Model of the first hypothesis of virtual reconstruction, Arch of access to the Forum of Constantine, Maxon Cinema 4D.



Fig. 7. Model of the second hypothesis of virtual reconstruction, Stoa Severiana, Maxon Cinema 4D



Fig. 8. Model of the third hypothesis of virtual reconstruction, Temple dedicated to Athena, Maxon Cinema 4D

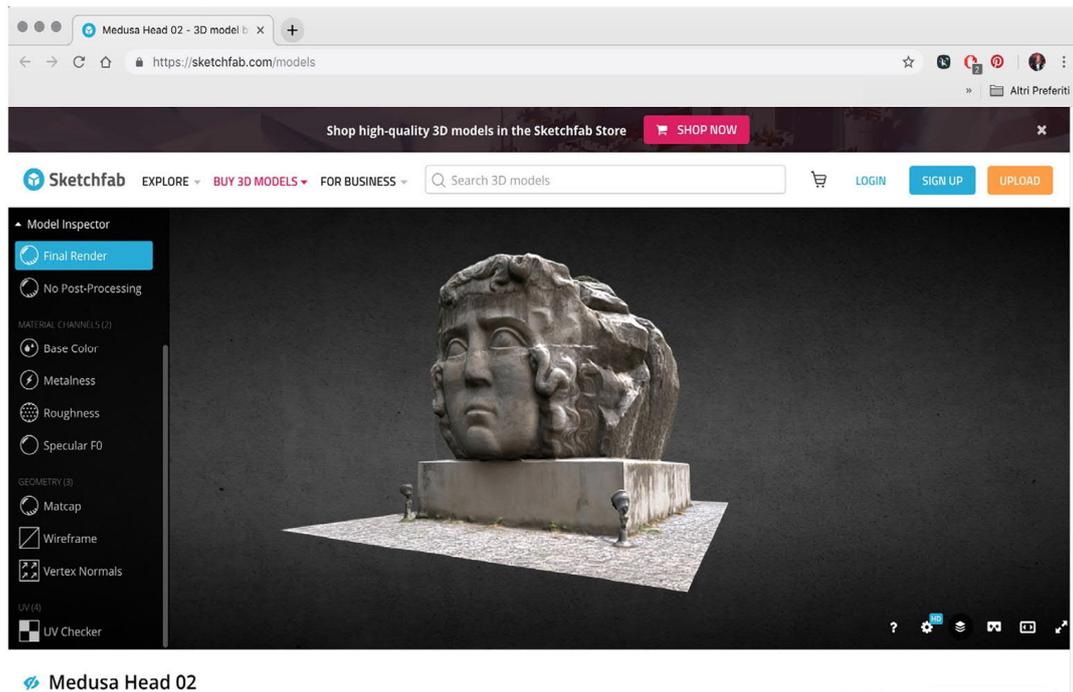


Fig. 9. Screenshot from the Sketchfab Platform, used for sharing online the 3D models and the VR content



Fig. 10. Example of QR code to be scanned, it allows a direct access to multimedia contents

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