The Island Ventotene: From a Story of Mediterranean Isolation to the Digital Survey and Interpretation of the Baths Area in Villa Giulia

CAROLINA BARZACCHINI and MIRCO PUCCI, Dipartimento di Architettura, University of Florence, Italy
GIOVANNA PATTI, Ventotene archaeological museum, Italy

Villa Giulia is a *villa d'otium* of the Augustan Age on the island of Ventotene. This research concerns the archaeological site of the baths area and their heating systems. The analysis aimed at investigating the site and providing some material that would allow further studies. The first step was a 3D laser scanner survey to ascertain the current situation of the ruins and to obtain a digitalization of the area. The survey resulted in a better understanding of the design and the logic of composition of the baths to determine the technologies used in the heating systems. In addition, the analysis focused on the digital reconstructive hypothesis of the *piscina calida*, a tank of the thermal path in Villa Giulia. The *piscina calida* was chosen because it is a rare example in its kind and size, as well as for the innovative technologies used in its heating system, like the so-called *samovar*. An in-depth study into the type of maritime *villa d'otium* and the functioning of the Roman baths was necessary for the reconstructive hypothesis. This was based on the digital survey and the "retro-progettazione", a solid and progressive, as well as reverse-designing method. The analysis led to a scientific representation of the possible volume of the *piscina calida*. Furthermore, this three-dimensional model contributed to show its value as a historical and archeological heritage.

Key words:
Digital survey, 3D reconstruction, 3D laser scanner, Ventotene, Villa Giulia.

CHNT Reference:
Carolina Barzacchini et al. 2018. The Island Ventotene: From a Story of Mediterranean Isolation to the Digital Survey and Interpretation of the Baths Area in Villa Giulia.

VILLA GIULIA IN VENTOTENE: AN EXAMPLE OF MARITIME VILLA

Ventotene is a volcanic and beautiful island in the Mediterranean Sea. It is located in front of the coast between Rome and Naples. Tuff characterizes the whole territory and it is an essential element for the development of the island. Villa Giulia was built when Ventotene reached its height in the Augustan Age. The Emperor August brought peace and regained its control over the Mediterranean Sea [Eck 2000], and many luxurious villas began to appear along the coast from Rome to Naples [Marzano 2010]. This stretch of coast was considered particularly strategic in the Roman Age due to its proximity to Rome and the amenities of the Roman baths, a perfect combination of *otium* and *negotium* [Purcell 2001].

Villae d'otium are luxurious houses in which Romans used to go for leisure [Romizzi 2001]. A common feature of the different types of maritime villas is a deep symbiosis with nature obtained through panoramic terraces and pavilions on multiple levels.

Imperial maritime villas are characterized by a series of pavilions and other architectural elements located in different points to highlight the island's unique views [Lafon 2001]. The residential part of the villas was destined for leisure and was designed according to aesthetic rather than functional criteria.

Authors addresses: Carolina Barzacchini, Dipartimento di Architettura, University of Florence, Italy; email: carolinabarzacchini@gmail.com; Mirco Pucchi, Dipartimento di Architettura, University of Florence, Italy; email: mirco.pucci@gmail.com

Fig. 1. Position of Villa Giulia in Punta Eolo, the extreme point of Ventotene

On the contrary, the productive activities were carried out in the *domus*. The maritime quarter was a lively place thank to its fishery [Mielsch 1999]. Maritime villas mirrored the Emperor's lifestyle, a combination of *amenitas* (leisure) and *fructus* (yield) which suggests the importance of business, arts and culture as source of richness, power and prestige in the Roman period [Marzano 2010]. The baths were the symbol of this idea of both business and leisure including four main sectors: *apoditerium*, *frigidarium*, *tepidarium* and *calidarium* and were based on the classical architectural dictates of exposition and orientation in order to enlighten the rooms and the main paths. The baths were in a separate area of the villa and were often in close contact with the sea [Swoboda 1919]. In addition, they had a social role for business meetings and cultural debates [Bellini delle Stelle et al. 1998].

VILLA GIULIA

The Emperor August ordered the construction of a *villa d'otium* which was called Villa Giulia. The villa had also a political function: it served as a place for the exiles of the Julio-Claudian dynasty. August's daughter, Giulia, was the first person to be exiled on the island and the villa was named after her [Braccesi 2014].

Villa Giulia was built in Ventotene because its climate was pleasant and the landscape was flat compared to the nearby islands, and the construction of buildings was quite easy due to the presence of tuff [De Rossi 1986] (Fig. 1).

The urban complex in Roman Ventotene included the Imperial villa, the port, the fishery and water supply tanks (Fig. 2).

Villa Giulia is located on the extreme point of the island. Its surface has been reduced due to the erosion of wind and sea and the extraction of tuff over the centuries. The maritime villa was divided into three sectors: the *domus*, the central garden and the northern area. The *domus* had a productive function, the central area linked the *domus* promontory to the villa through a scenic stairway and the northern area was the nearest to the sea sector, the living quarters and the baths.

Fig. 2. Roman Ventotene

VILLA GIULIA: THE BATHS

The northern area has two different geographic orientations: the garden area is oriented on a north-south axis, while the baths and the living quarters are on a north-eastern and south-western axis to exploit best the sun and to provide shelter for the winds. The baths pavilion included several pools and some service rooms next to each other and ended with a stairway direct to the sea (Figs. 3 and 4). The *apoditerium* (the dressing room) introduced the thermal path. On its right, there were the heated rooms: the rectangular-shaped *tepidarium* whose *suspensurae* were used as a heating system and the *calidarium* (Fig. 6). The Ventotene baths housed a grand *piscina calida*, a circular-section pool with innovative heating system, the *samovar* (Fig. 5). The *piscina calida* had a capacity of 150,000 liters and weighed 200kg/m^2. It was a facility which offered high performance and a large space, a true prototype for the future imperial baths, but especially the greatest and largest example of a *piscina calida* in all of the ancient architecture. Built in more recent times, the c*alidarium* had a rectangular shape with an exedra on its smallest side and it was provided with a proper technical room and a hypogeum oven. The *calidarium* was not aligned with the previous basin, thus suggesting that it was built later as a hot pool. The thermal path ended with the *frigidarium* which was on the left side of the dressing room. The descent to the basin opened to magnificent stairs and its floor included a decorative dolphin which is still visible today. The thermal area is the best preserved section of the villa but it is destined to be destroyed by wind and coastal erosion [Sabbioni et al. 2008]

.

Fig. 3. Villa Giulia's baths area

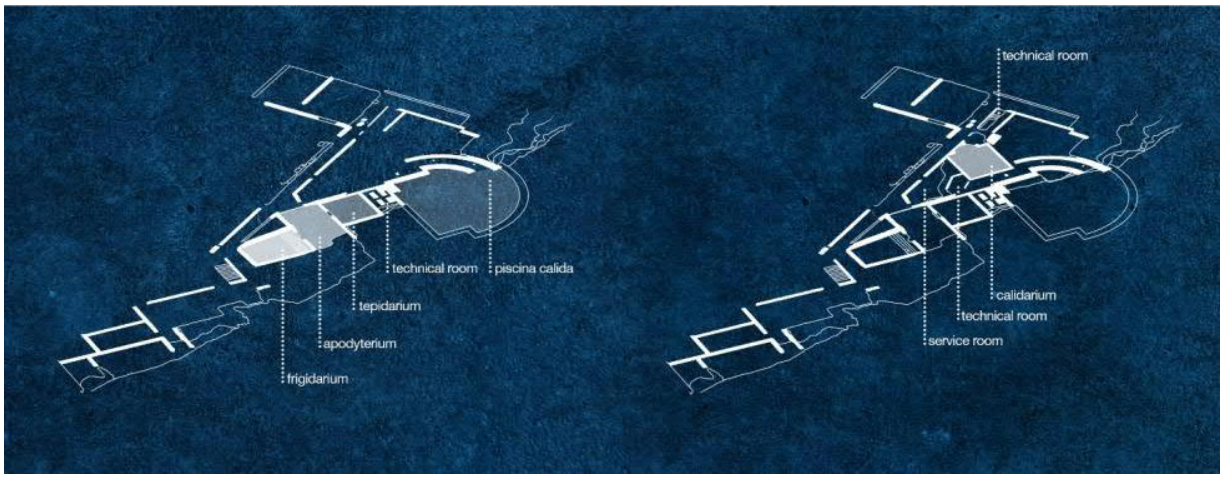
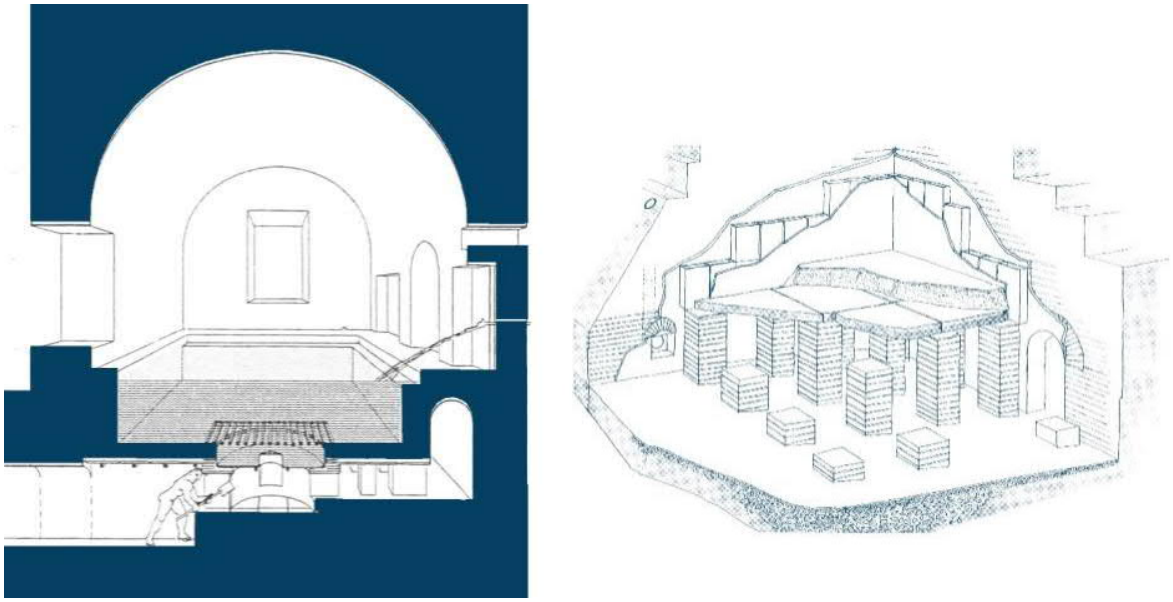


Fig. 4. Rooms of the baths area



FigS. 5-6. Samovar heating systems (piscina calida) (left) and suspensura heating system (tepidarium and calidarium) (right)

NECESSARY DIGITAL SURVEY

The latest surveys of the remains of Villa Giulia in Ventotene date back to the archaeological excavation campaign carried out in the 80s. The aim of the survey is to describe the current state of the archaeological area, to create a digital record of the Roman remains and to provide information, as well as to create a project of conservation and promotion of the site. The survey took place in two days in July 2017. The day before the survey all the technical operations were planned on site. First, the targets were positioned at the end of the *domus rustica* stairway in order to have a reference zero point for the recording. The few targets were positioned on points which were visible from more than one station, so that at least three non-aligned points with neighboring stations could be seen from each one [Bini and Bertocci 2012; Docci and Maestri 1994]. Then the equipment was put along the west coast of Punta Eolo, where the thermal area was, and followed the difference in height up to the other areas. On the first day the survey finished at sunset with many difficulties due to strong wind and on the second the station number was increased compared to the first plan to have a complete coverage of the area (Fig. 7). The survey with laser scanner was aimed at giving a precise representation of the Roman remains thanks to the digital tridimensional and more detailed model. A contactless survey of the remains of *villa d'otium* was required due to the size and characteristics of the complex and it was carried out by using devices able to detect distances and angles through remote analysis. This resulted in the collection of a great deal of data in a short time.

A 3D laser scanner called Faro X 330 (Fig. 8) was used as necessary equipment to briefly detect a very large area also characterized by various differences in soil levels. The result was a detailed description of the archaeological remains and a measurement of elements which were otherwise not easily accessible. However, strong wind in Punta Eolo hindered the contactless survey due to the oscillation of the device which couldn't be lifted much. The movement could have resulted in a graphic disturbance with blurred images which could not be recorded.

The survey required a large amount of high and medium intensity scans. These were carefully selected to avoid the development of areas lacking in data due to the presence of (temporary or permanent) obstacles located between the scanner and the object to be detected. In total, 133 scans were performed, resulting in a point cloud of the whole digital 3D model of 445.120.000 points.

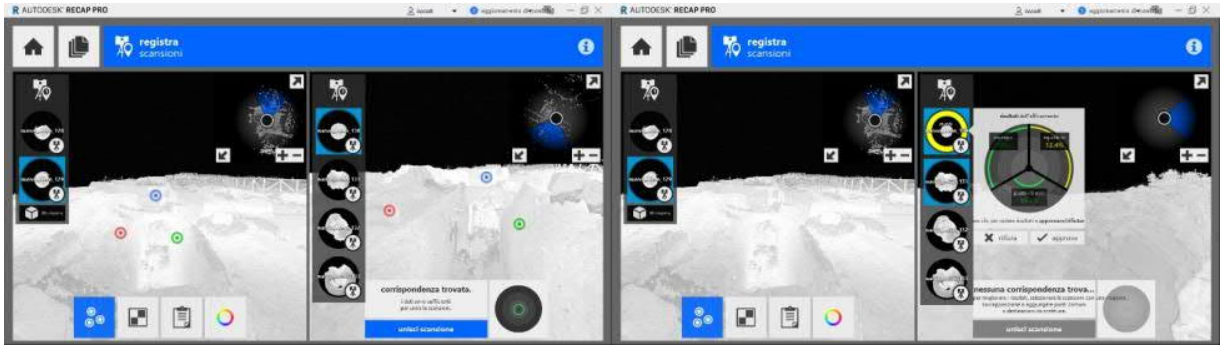
In an architectural survey, the laser scanner plays an essential role as non-invasive and non-destructive diagnostic survey method and it is perfect for sensitive sites such as the remains in Villa Giulia. It was therefore possible to obtain global digital data on which all the stages of subsequent reprocessing and representation could be carried out [Guidi et al. 2010; Guidi 2014].

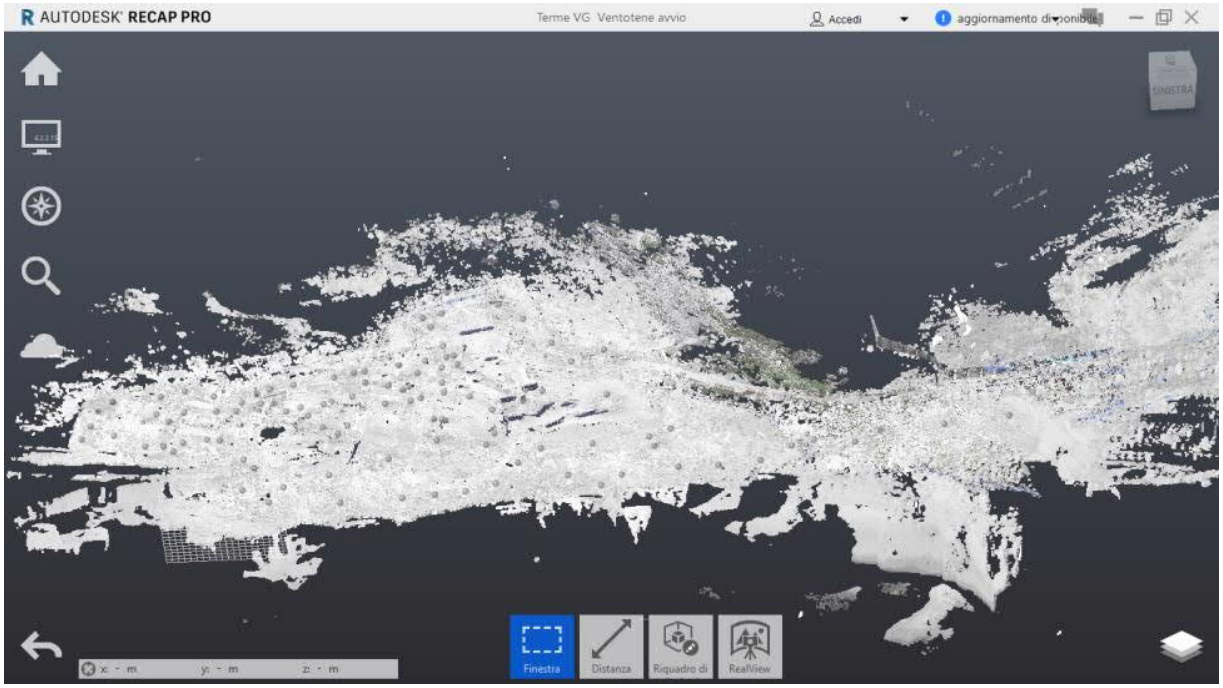
Fig. 7. Laser scanner stations

Fig. 8. 3D laser scanner Faro X 330

THE GRAPHIC REPRESENTATION OF THE SURVEY. CREATING A POINTCLOUD WITH THE RECAP SOFTWARE

The survey was followed by the processing of data on site and the graphic representation. The identification of the most appropriate solution to achieve an adequate result for such a survey was significant [Remondino 2014; Apollonio 2016]. This meant sometimes abandoning the canonical procedures and experimenting with new alternatives. The processing of the digital survey data was carried out with the use of the scanner recorder Autodesk ReCap Ultimate 360. This operation, taking place automatically thanks to systems which use "Iterative Closest Point" (ICP) algorithms, consists in aligning a pair of point clouds based on three known points – identified manually or geometrically – which must be common to the two scans to be recorded and not aligned. The recording is concluded if all the three parameters set by the program (balance, overlap and points > 6 mm) reach an adequate percentage of collimation (Fig. 9). The scans were then aligned to obtain the final cloud: a navigable 3D model which preserves the real scale for each recorded element and enables a subsequent reprocessing through specific software (Fig. 10).





Figs. 9-10. Scanner recorder operations (top) and final 3D cloud (bottom)

FINAL RECORDS. CREATION OF DRAWINGS AND SECTIONS WITH BENTLEY POINTOOLS 8VI SOFTWARE

The final cloud gives a much more real representation of an object than the traditional 2D drawing. However, it is necessary to convert the cloud into plans, elevations and sections. The phases of subsequent work were performed by using both software which reprocesses the general point cloud and the Bentley Pointools 8vi which imports the scans, edits and segments the clouds, as well as making orthophotos. First, the Autodesk Recap file was converted into a compatible file with Bentley Pointools 8vi. The advantage to use this software is to have plans and sections geometrically defined by a system of Cartesian axes (x,y,z) and by an axis rotation around the z. This technology enables a highly accurate geometrical representation of the data. The creation of drawings and sections took place through a Clip Box (Fig. 11), a 3D box which can be rotated and resized in order to isolate the required model parts and hide everything outside it. In this way, the model is reduced in orbit and the program will later calculate fewer points, thus accelerating the procedure. This is the reason why this procedure was chosen. By using the Plane Shader function, it is also possible to establish a repetition range for the chromatic scale, as well as its repetition direction along an axis of the model reference system (Fig. 12). This last option was essential because in the different set views the depth, the distances, and the stratifications of the remains could be immediately detected. The Pointools raster snapshots were imported into Autocad for the 2D drawing to facilitate the measurement and dimensioning of the detected elements and have plans, elevations and sections.

The Digital Canon 1300D reflex camera was used to support the laser scanner survey and to produce high definition photos. These photos were useful to better see the materials and details of the remains for the Autocad 2D drawings. The photos were taken when it was cloudy to avoid the shadows on the objects.

The representation concerns the drawing of the area and 13 sections: two along the axis of the residential part of the villa and 11 in the thermal area. The post-production in AdobePhotoshop CS6 of the images was useful to clear the data from any "noise" generated during the scanning.

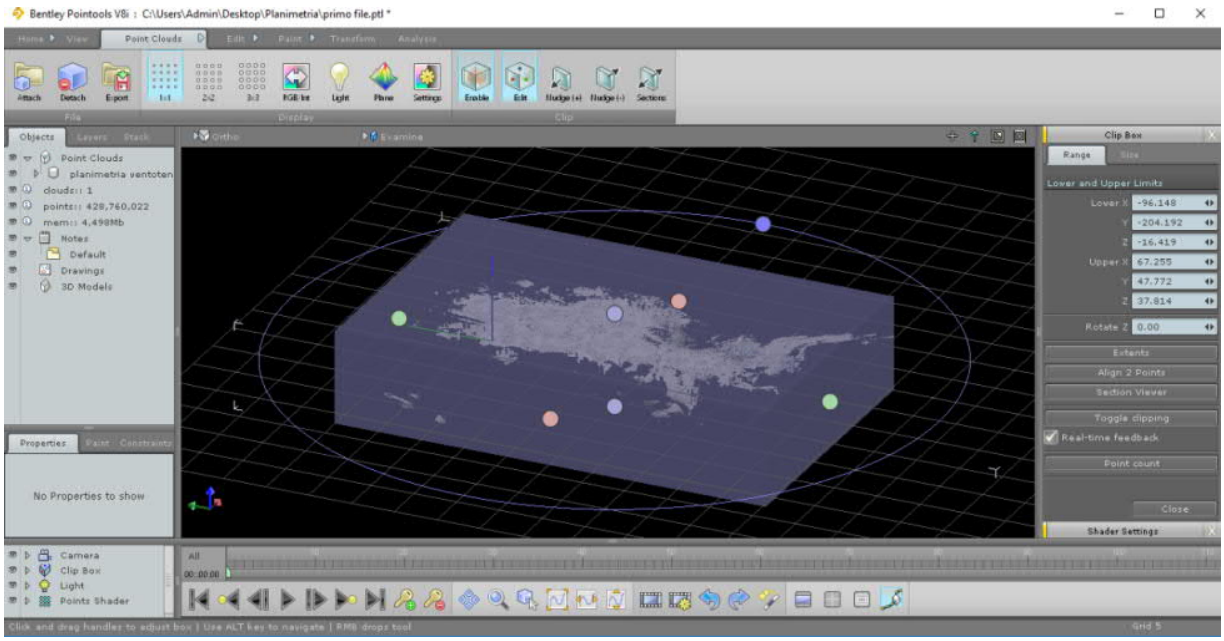


Fig. 11. Clip box

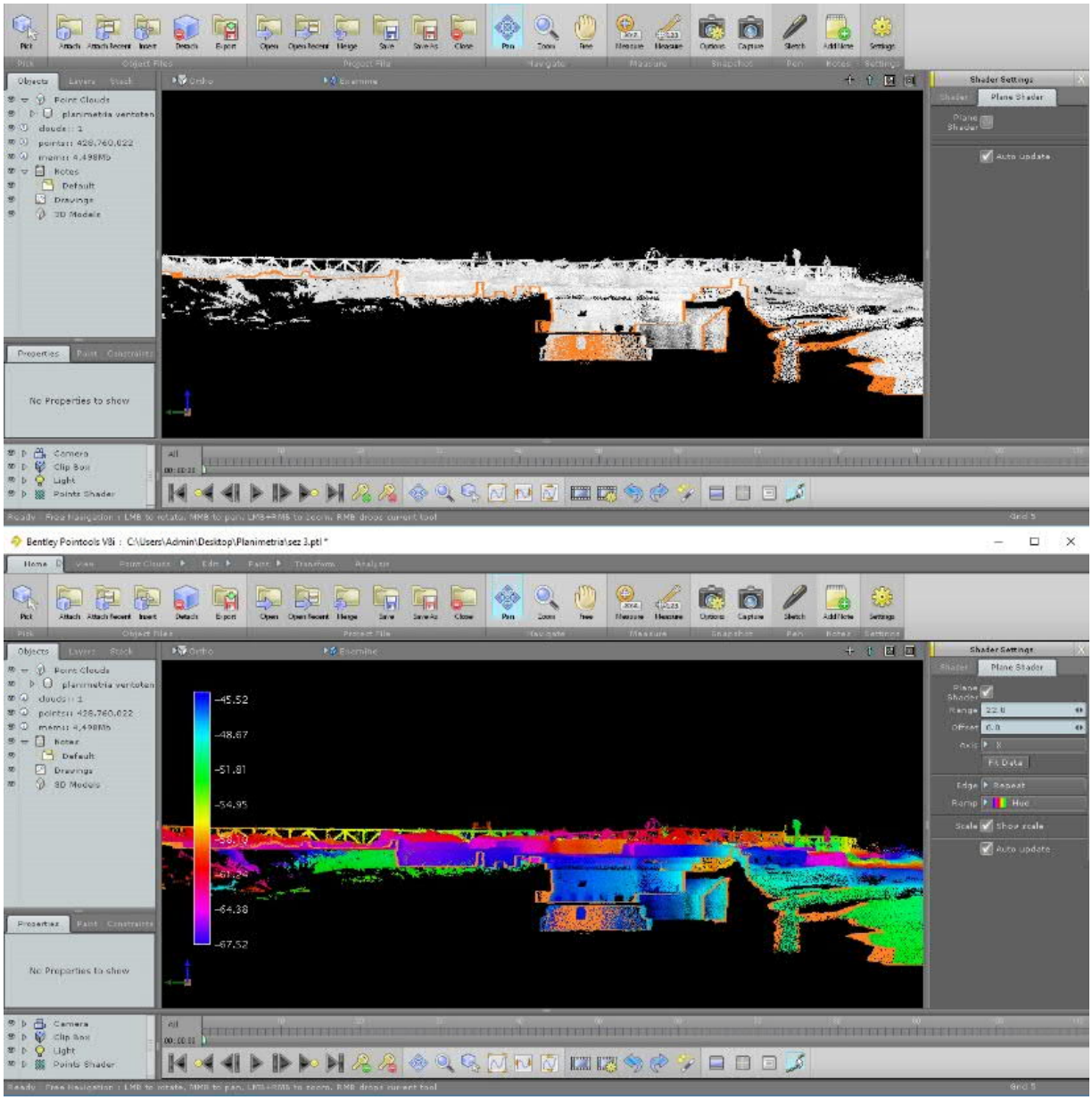


Fig. 12. Plane Shader function

THE RECONSTRUCTIVE THEORIES

The survey describes the current state of the remains of the Roman villa in Ventotene and provides an essential starting point to build a reconstructive plan and the subsequent virtual reproduction of the baths of the *piscina calida* in the thermal area. The reconstruction aimed at representing the volume of the baths as it was in the Roman era and at providing a new interpretation of the place so that the scientific data resulting from the survey is consistent with the reconstruction plan [Blanco et al. 2009].

The *piscina calida* was subject to research for its splendour and impressive volume which exploited the natural difference in level of the tuff rock and for the interesting elements that it still preserves, like part of the heating system. This basin was a rare example for the ancient baths and its use in a private place was a symbol of social prestige.

The approach to the reconstructive analysis was that of researching and understanding the original projects and studying the building techniques of the time, as well as the cultural and technical aspects related to the type of Imperial *villa d'otium*. In order to avoid misinterpretations and to validate the reconstruction plan, it was necessary to be familiar with the relative architectural period and historical time [Blanco and Pucci 2010].

Many variables came into play when interpreting this data. It was necessary to collect all the information available related to the reasons why the villa was built:

Project intentions – Roman structure – Roman construction – Historical information – Roman buildings measuring units – Roman cultural aspect – Geometric schemes – Archeological consultancy – Possible change in time – Comparison with baths area.

The following aspects are those taken into account – and set by the London Charter [2009] and the Sevilla Principles [2011] – when approaching a digital reconstruction: quoting the sources and mentioning the technological devices used, referring to the followed logical process, as well as providing with adequate photographic records and with stylistic observations and typological comparisons.

The reliability of the reconstruction plan varies from case to case. It is more reliable in relation to the plan but less reliable for the facades, given the total lack of vertical walls, and very hypothetical regarding the roofing.

THE RECONSTRUCTION OF THE *PISCINA CALIDA*

Today, only a part of the *piscina calida* is still firmly fastened to the difference in height that occurred after the collapse of a large part of the massive structure. With a visible trace in the ground, at the beginning of the difference in height, it is possible to understand the size of the structure. The *piscina calida* was entirely built of tuff rock, inside which there were the dressing rooms and the multilevel heating system. After the collapse of a part of the structure, the *piscina calida* can be described in sections. From the marks left on the walls and on the ground as well as from the materials found there it is possible to reconstruct the depths of the baths and the heights of the hypogeum. The villa was obviously changed over time, both in its function and in its constructive and technological techniques. This was essential to achieve a suitable construction plan.

After having collected all the information it was important to choose the right software for the 3D reconstruction. Maxon Cinema 3D + VRAY was used to validate the result of the reconstruction. Reconstructing and verifying the plan of the *piscina calida* with the Autocad software was necessary to move from the 2D to 3D representation. The plan was imported into Maxon Cinema 3D + VRAY where the parts were developed gradually. Plans, elevations, and sections were obtained with horizontal and vertical layers in certain points to better understand the volume.

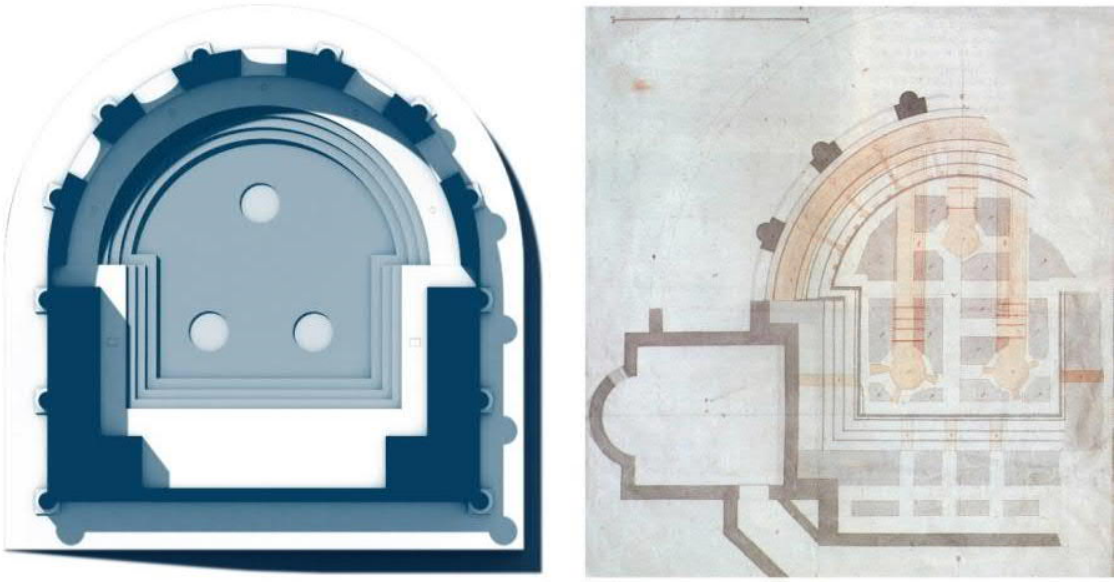
THE PLAN

The elements supporting the “retro-progettazione”, the reverse designing of the original ideas behind the building, were especially the contactless survey, the measurements carried out on site and the drawing of the 18th century *piscina calida* which is currently at the State Archives in Naples.

Thanks to these records it is either possible to verify the state of conservation of the drawing of the baths in 1700, which remains in its entirety, or deduce its proportions and measures. The 2D drawing result was used as a reference and compared with the measurements of the survey campaign, as well as with the historical drawing. As soon as the pooling axes were identified, the curve of the steps was added to the drawing to complete it.

Once the arch and the symmetry axes have been obtained, they were matched with the detected part to understand the missing one. Then it was compared to the 18th century drawing, appropriately reported in scale, and it was then clear that the measurements matched perfectly. This reconstruction is realistic, because the referred sources and the obtained measurements, both direct and contactless survey, led to the same result with minimal differences (Fig. 14).

Fig. 13. Piscina calida in Ventotene



Figs. 14-15. Reconstruction of the plan (left) and drawing of the 18th century (right)

THE HEATING SYSTEM

The survey focused on other aspects too, like the records and the various heating systems in Roman thermal baths, the technology used, as well as the similar models in other villas and thermal baths of the same historical period of Villa Giulia. Also in this case, the reference used to verify the first findings and comparisons was the eighteenth-century drawing. Matching the drawing and the return of the surveyed section, it was possible to reconstruct the height of the rooms under the pool (Fig. 16). The reconstructed heating system of the tuff rock at the lower level was composed of three brick corridors of the hypogeum with a vaulted roof, which was accessible through a small annular corridor.

The roof was understood to be vaulted, not only through comparisons with other structures and material in literature, but also on site. It is in the façade that it is possible to recognize the springer of the vaulted roof. Traces of rust shown in red in the 18th century drawing and suggesting four metal bars were also found on site and were used to match the rooms of the furnace with a flat section. The three tunnels – the central one is shorter in order to heat the entire floor of the baths – ended in circular spaces, the kilns, where the fire was lit and whose heat was then dissipated in the system.

The kilns were placed higher than the tunnel; a step separated the entrance to the combustion room on which was placed a thick wall in tuff so as to prevent the fumes from filtering into the tunnels used by the staff. The mouth was placed at the top and the ducts were small, undoubtedly to disperse as little heat as possible. Considering the remaining section of the wall, the three galleries are about one meter high.

The heat of the kilns spread through three openings into a compartment, the hypocaust, placed a little higher between the suspended floor of the baths, the *suspensura*, and a subfloor.

The hypocaust in Ventotene is a rare example of compresence of the metallic vertical elements and the brick columns, the *pilae*, which supported the suspended ceiling. The presence of the metal grid is proved by its traces behind the curvilinear wall of the baths. The iron grids were connected to the intrados of the baths floor, and fastened to the external wall. The very evident traces measure 7 cm x 7 cm on the base of the air space and had the function of fastening the metal grid to the perimeter walls [Amici 2015]. This technique was used to promote the circulation of hot air inside the hypocaust, freed by brick obstacles, thus improving the heating of the upper baths. Moreover, iron was used in Roman times in projects with significant financial resources or large thermal buildings.

Considering that Villa Giulia is an imperial villa, this material is very likely to have been used. The great financial investment used for this type of advanced technology and the associated cultural prestige created a stimulating environment for new constructive solutions.

Finally, above the three circular kilns was the *samovar*, a metal container supported by *pilae* on the sides of the combustion chambers, whose convex part was in direct contact with the pool water and embedded in the baths floor. The water was heated by induction from the contact with the samovar. Similar examples of a *samovar* system can be found in the baths of Massaciuccoli and suburban baths in Pompeii. These models were analyzed to study their characteristics and technological solutions.

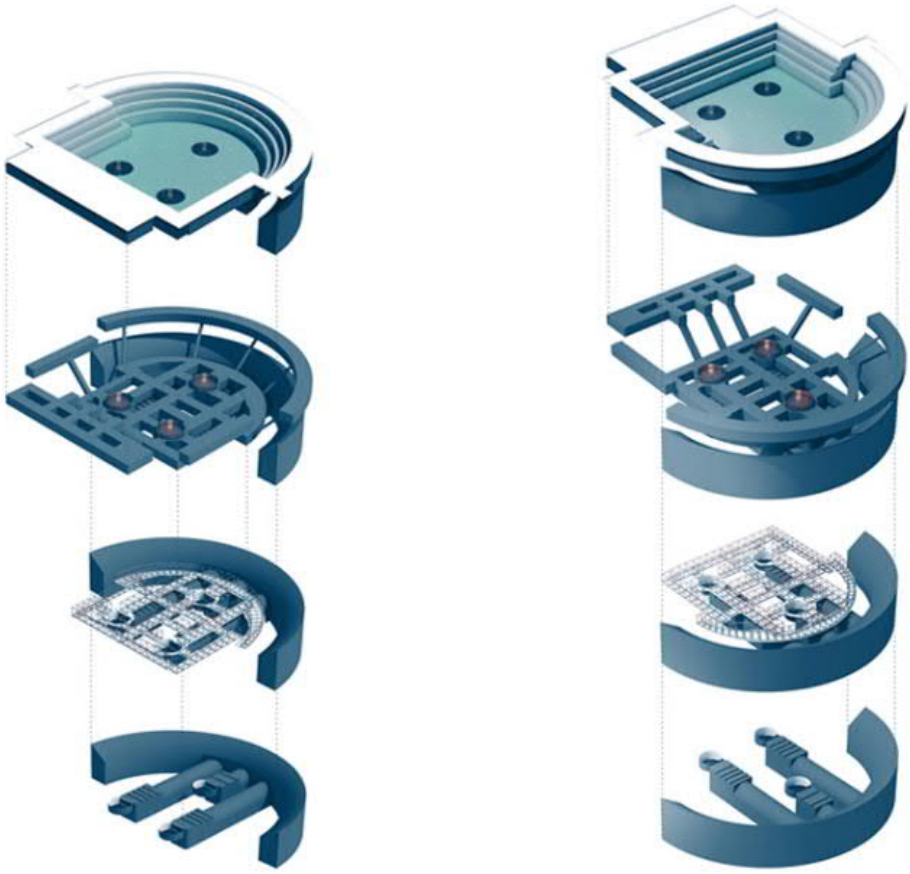


Fig. 16. Heating system of the piscina calida

FACADES

With only the remains of the thermal baths it is difficult to reconstruct the height of the walls. It could be inferred through the proportions between the parts of the structure and by comparing them with the relevant references of the period and the typical measures of the Roman construction methods. Starting from these considerations and taking as a reference the structure of the *piscina calida* in the Suburban baths in Pompeii – whose walls can be easily recognized unlike the one in Ventotene – the perimeter wall must have been 5 meter high.

The traces on the ground of the two columns placed against the base of the outer ring make possible to identify the molding step on the external walls. All the moldings characterizing this architectural element have been reconstructed, relying on the typical measurements and proportions of this ornamental part. The openings must have been on the curvilinear part, given its southern exposure. In this type of structure they were calibrated so as to offer a good lighting with minimum heat dispersion. The section of the windows was proportioned according to the part of the wall which they were going to occupy. In terms of shape, however, the windows look like those in the Pompeii Suburban thermal baths [Cairoli 2006].

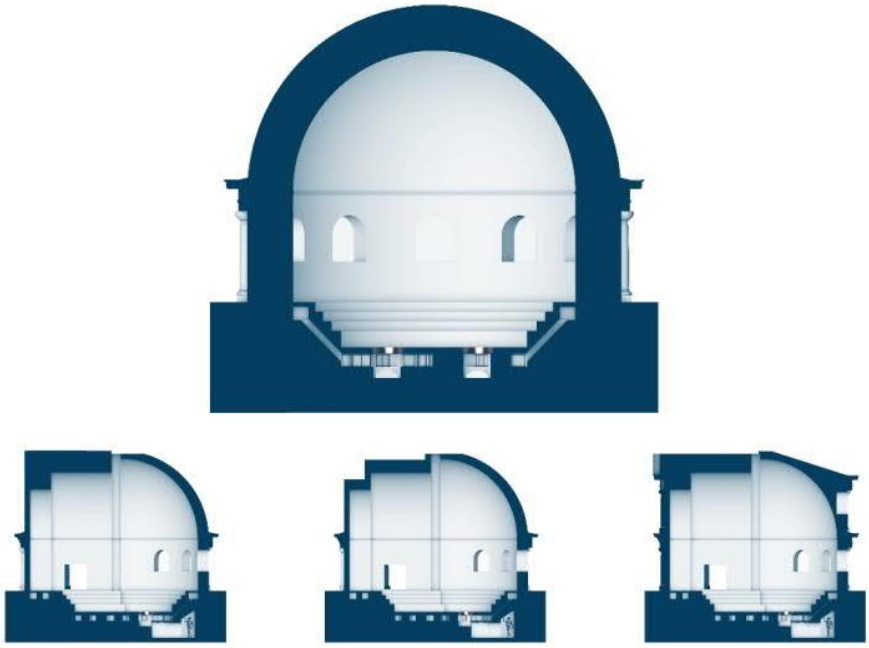


Fig. 17. Sections of the piscina calida

THE ROOF

The “retro-progettazione” [Verdiani 2017] was the most challenging part of the structure due to the total lack of findings (Figs. 17 and 18). This shows that it was built in tuff, so it was lost once it collapsed. Looking at the drawings, the roof must be subdivided into three parts. The two parts above the rectangular-sectioned rooms most likely had a semi-cylindrical vaulted roof, while the other a semi-dome one, given the circular shape of the underlying wall. Also, a joined arch connected the semi-dome with the adjacent roof. The heights of the three parts were retraced by matching the curve of the arch, that of the semi-dome and that of the two adjacent roofs. This is the first theory simply based on geometric rules and proportions [Marta 1990; De Angelis D’Ossat 1993]. An upper dome which joined the roof is thought to have been there so that the heights of the spaces remained unseen. This solution could have balanced the façade, but it could have also resulted in a larger amount of heavy material and a strong pressure on the underlying wall. There is also a third theory – the most convincing one – which states that there must have been a double order of moldings and openings and a tympanum in the north wall at the end of the roof and a buttress in the upper part of the opposite façade. This is a solution that revokes the great buildings of the Imperial era [Adam 1999].

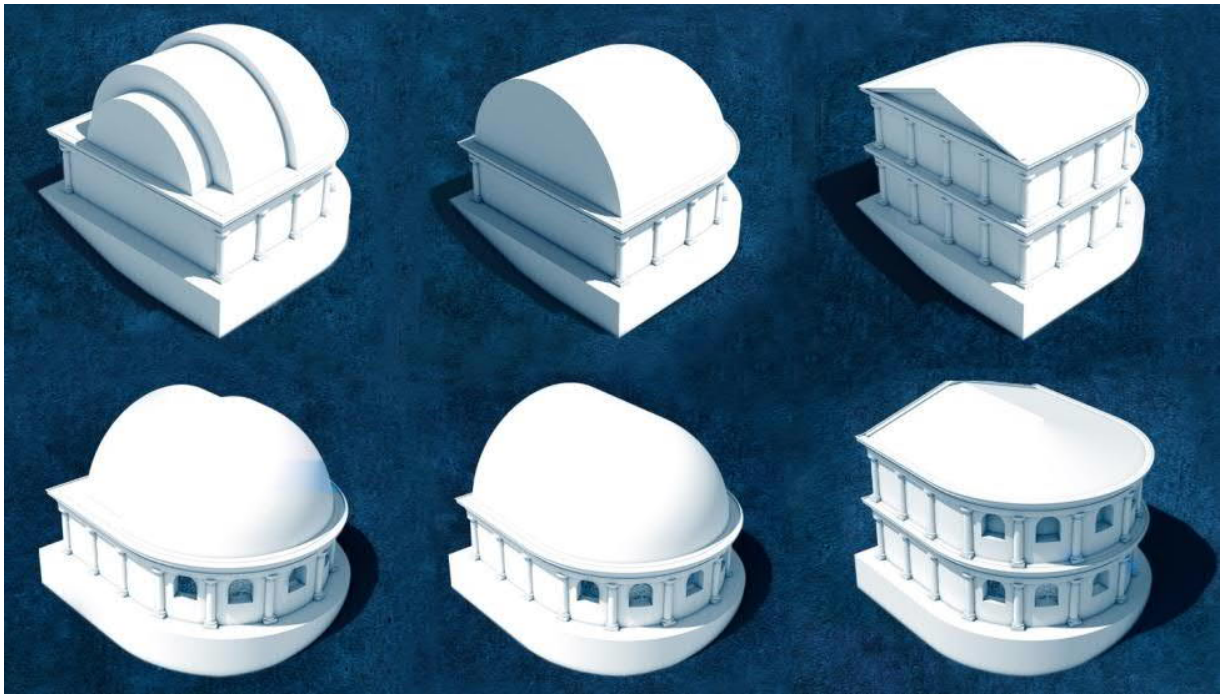


Fig. 18. Three different theories of the roof

Three reconstructive plans have been proposed to respect the methodological principle of the London Charter according to which, in controversial or particularly challenging cases, the right thing to do is to suggest more solutions in order to stimulate critical analyses and constructive discussions [London Charter 2009]. According to all the theories there are neither lateral openings above the vault springers, nor oculi in the semi-dome, as this type of solution was typical in *calidaria*.

Right in front of the thermal pool there is a trace of a buttress which was placed against the slope so as to contain the pressure exerted by the large structure. The buttress is thought to be as high as the villa.

The process of reconstructing the *piscina calida* was based on the principles of London Charter (implementation, aims and methods, research sources, documentation, sustainability, access) and of Seville (general criteria, guidelines, sensible use of technology, research, new methods and digital techniques, virtual archeology awareness) which includes rigorous methodological standards to be strictly observed to provide scientific authoritativeness and promote a technical and intellectual accuracy in the study and interpretation of digital display [London Charter 2009; Sevilla Principles 2011].

The graphic representation was not coincidental. It was aimed at highlighting the volume of the *piscina calida*.

The non-realistic no-texture renders were made using Maxon Cinema 3D + VRAY and by setting the light and the shadows (Fig. 19). Then the most appropriate cameras were chosen to enhance the representation of the objects to obtain a clear and communicative image for all the visitors.

Fig. 19. Exploded diagram and level of reliability of the piscina calida (orange: low; yellow: medium; green: high)

CONCLUSIONS

This research is the result of a collaboration with Dipartimento di Architettura, University of Florence and the municipality of Ventotene. The analysis was aimed at investigating the archaeological site of the baths area and their heating systems and providing some material that would allow further studies. The digital reconstruction ultimately is aimed at creating a connection between history and science: the remains of the past and the scientific research that was necessary to show the value of the architectural objects. The survey and digital reconstruction has transformed forms of communication and understanding into the representation of what was lost. This project was based on a solid approach supported by the use of survey software and tools, as well as the "retro-progettazione" (reverse designing), and was inspired by the unique cultural intelligence, socialization, and history of Villa Giulia and the island. The understanding of the type of maritime villa d'*otium* and the functioning of the Roman baths required an in-depth study of a lot of material found in Ventone's library and in literature, showing that the thermal baths of Villa Giulia were an important cultural heritage and a rare example of the Roman baths in a maritime villa. The 3D laser scanner survey was used to ascertain the current situation of the ruins and to obtain a digitalization of the area. The digital survey was the perfect tool for an archeological site and its high level of detail. Today the digital survey has become essential for any cultural heritage recording and understanding. The cultural and historical context and specific standards of the London Charter and the Sevilla Principles validated the digital reconstructive hypothesis of the *piscina calida*. 3D modeling enabled a deep understanding of the remains, the geometry of the building and the samovar heating system. The digital reconstructive hypothesis of the *piscina calida* was compered to example of reference (suburban baths in Pompeii and the baths in Massaciuccoli) and analyzed by Alessandro Blanco, an expert archeologist of thermal baths. The volume of *piscina calida* was represented for the first time thanks to this research and it will be available for scholars, educational purposes, and visitors, and as a base for further research. In the near future all the information can be found virtually or interactively on a dedicated website or with the help of a QR code, directly on site with a mobile phone. The digital reconstruction tends to have a crucial cultural role in our time with the aim of enhancing the comprehension and safeguarding historical-archaeological heritage.

ACKNOWLEDGEMENTS

The "Dipartimento di Architettura", University of Florence has supported the digital survey campaign of the baths area in Ventotene; the operation was coordinated by Prof. Giorgio Verdiani. All the activities have been developed thanks to collaboration with the Ventotene municipality and in particular with dott. Ph.D Giovanna Patti, the former director of the archeological museum of the island.

The digital reconstructive hypothesis of the *piscine calida* has been done in full collaboration with dott. Ph.D Alessandro Blanco, from the Scuola di Dottorato in Archeologia, Roma La Sapienza, Italy, and arch. Mirco Pucci, Dipartimento di Architetura, University of Florence, Italy.

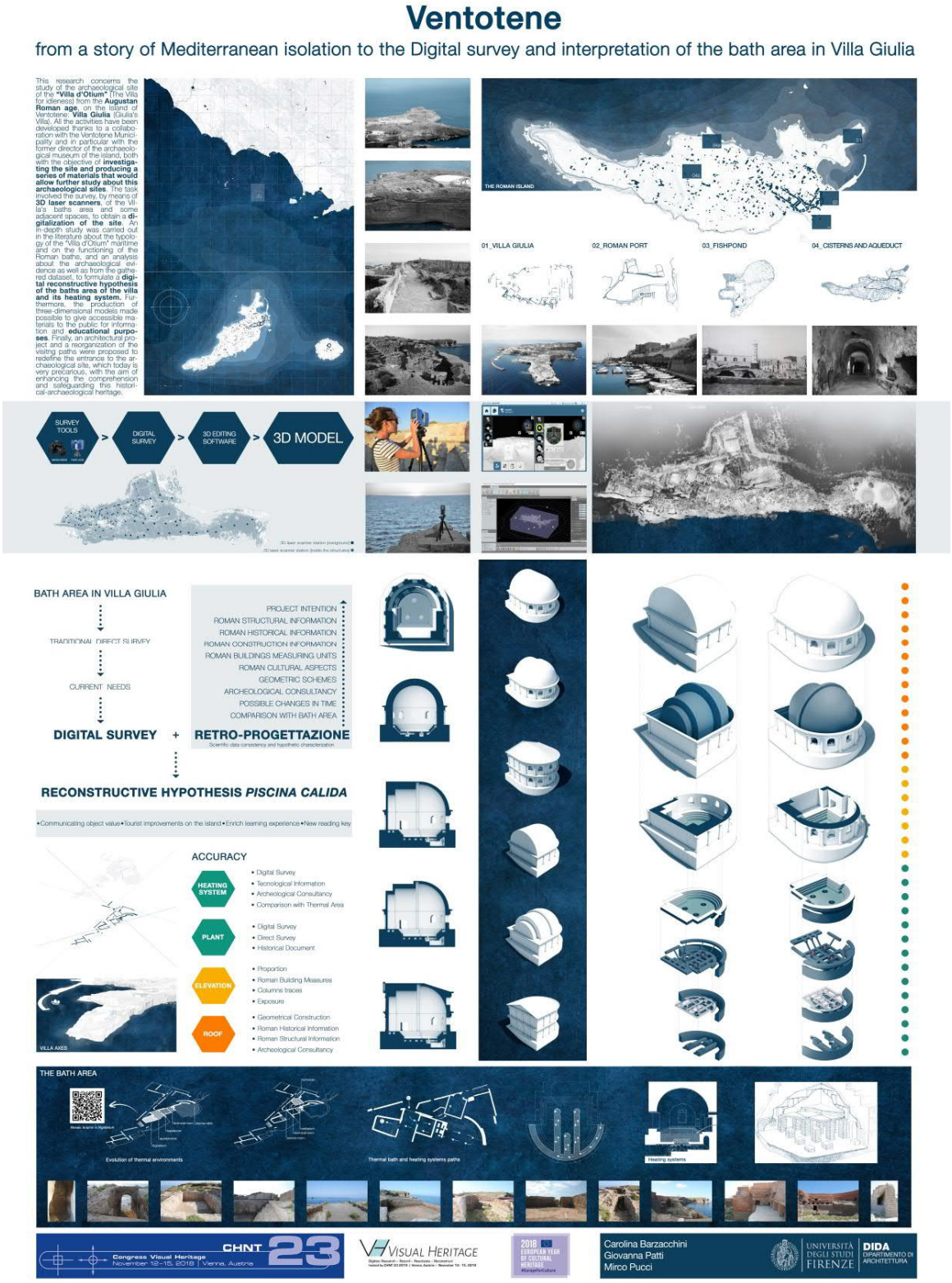


Fig. 20. The poster (original in UNI A0 format) as presented in occasion of the Cultural Heritage and New Technology / Visual Heritage Conference, Vienna, 2018

REFERENCES

Jean Pierre Adam.1999. Roman building art: Materials and techniques, Routledge.
Carla Maria Amici. 2015. Unusual Examples of sophisticated iron technology in the heating systems of roman imperial baths, European Journal of Archaeology 18 (4), 658–678.
Fabrizio Ivan Apollonio. 2016. Classification schemes and model validation of 3D digital reconstruction process, in Proceedings of the 20th International Conference on Cultural Heritage and New Technologies 2015 (CHNT 20, 2015) Vienna 2016.
Francesca Bellini delle Stelle, Mannari Anna, and Roberto Sabelli. 1998. Terme romane e vita quotidiana, Modena, Panini.
Marco Bini and Stefano Bertocci. 2012. Manuale di rilievo architettonico e urbano, CittàStudi, Torino.
Alessandro Blanco and Mirco Pucci. 2010. Ad thermas: a system between private and public life in the ancient town, in Proceedings of the 15th International Conference on "Cultural Heritage and New Technologies" Vienna, 2010.
Alessandro Blanco, Mirco Pucci, and Giorgio Verdiani. 2009. The Small Baths in Hadrian's Villa. A ground test for enhancing the approach to the digital survey and reconstruction for archaeologists and architects, in Proceedings of the 14th International Conference on "Cultural Heritage and New Technologies" Vienna, 2009.
Lorenzo Braccesi. 2014. Giulia, figlia di Augusto, Bari, Editori Laterza.
Fulvio Giuliani Cairoli. 2006. L'edilizia nell'antichità, Roma, Carocci editore.
Guglielmo De Angelis D'Ossat. 1993. La forma e la costruzione delle cupole nell'antichità romana, in Atti del III convegno nazionale di storia dell'architettura, Roma, pp 227.
Gian Maria De Rossi. 1986. Le isole pontine attraverso i tempi, Roma, Guido Guidotti editore.
Werner Eck. 2000. Augusto e il suo tempo, Bologna.
Mario Docci and Diego Maestri. 1994. Manuale di rilevamento architettonico e urbano, Roma, pp. 39-42.
Gabriele Guidi. 2014. Terrestrial optical active sensors – Theory & applications. In Stefano Campana & Fabio
Gabriele Guidi, Michele Russo, Jean Angelo Beraldin. 2010. Acquisizione 3D e modellazione poligonale, McGraw-Hill Education, Milano.
Xavier Lafon. 2001. Villa maritima. Recherches sur les villas littorales de l'Italie romaine: III siècle av. J. C.- III siècle ap. J. C., Roma, École française de Rome.
London Charter for the computer-based visualization of cultural heritage. 2009.
Roberto Marta. 1990. Architettura romana. Tecniche costruttive e forme architettoniche del mondo romano, Roma, Edizioni Kappa.
Annalisa Marzano. 2010. Le ville marittime dell'Italia romana tra amoenitas et fructus, in "Amoenitas,Rivista di Studi Miscellanei sulla Villa Romana", 1, Roma, 2010, pp. 21-33.
Harald Mielsch. 1999. La villa romana, Firenze, Giunti.
Nicholas Purcell. 2001. Alla scoperta della costa residenziale romana: il lituslaurentinum e l'archeologia dell'otium, in "Castelporziano III. Campagne di scavo e restauro 1987-1991", a cura di Lauro M.G., Roma, 1998, pp. 11-32.
Fabio Remondino (Ed). 2014. 3D Recording and Modelling in Archaeology and Cultural Heritage-Theory and best practices.
Lucia Romizzi. 2001. Ville d'otium dell'Italia antica (II secolo a. C. -I secolo d. C.), Napoli, Edizioni Scientifiche Italiane.
C. Sabbioni, M. Cassar, P. Brimblecombe, and R.A. Lefevre. 2008. Vulnerability of Cultural Heritage to Climate Change, Report, EUR-OPA Major Hazard Agreement, Council of Europe, Strasbourg.
Sevilla Principles. 2011. www.arqueologiavirtual.com (last viewed on July 10 2008) Oxford: Archaeopress Publishers of British Archaeological, 37–60.
K.M. Swoboda. 1919. Römische und romanische Paläste. Eine architekturgeschichtliche Untersuchung, Wien, Kunstverlag Anton Schroll.
Giorgio Verdiani. 2017. Retroprogettazione, DIDAPress, Firenze.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz

The Kyrenia Castle, an Approach to Digital Documentation in the Cyprus Island

STEFANO BERTOCCI and GIORGIO VERDIANI, University of Florence, Italy
ALESSANDRO CAMIZ and ZEYNEP CEYLANLI, Özyeğin University, Turkey
MÜGE ŞEVKETOĞLU, Cyprus International University, Cyprus Island

Documenting large architectures with an accurate survey has recently become possible even with a limited budget. Digital survey tools based on both active and passive solutions, offers today versatile opportunities for the architectural documentation, regardless of the building's dimension. This paper presents the poster, prepared for the CHNT conference, with an extract of Terrestrial and Aerial Photogrammetry and Terrestrial Lasergrammetry. This was used by academics in the context of the Kyrenia Castle in the Cyprus Island, a large medieval fortification organized in an almost square planimetry with a side of about 150 meters and walls height up to about 30 meters, gathering the occasion of a specific workshop (activated for one week in May 2018) and producing the first (partial) digital model of this large built heritage. Following the protocols and best practice in digital documentation of this kind of architectures – the coordinator group of the workshop in synergy with the management unit of the museum hosted in the castle- has brought on an articulated experience moving from the morphology of the castle, to its stratigraphy, to its exhibition aspects, to its restoration issues, to the production of multimedia contents for technical and/or general public access. In that poster it was presented the structure of the workshop, the structure of the survey, the interactions and integrations between different surveys, the system of tools, and the results coming out at first, from the on-field operations brought on by the students participating to the workshop and the following processing operated by technical expert operators; going on to the development of common digital bases to evolve the way of approach to these monumental structures. To present the complete workflow with samples the poster was enriched with QR-Code links to online resources has been made to be a useful base for sharing and discussing the whole set of activities completed on this subject.

Key words:
Digital Survey, Integrated Survey, Kyrenia Castle, 3D Laser Scanner, Photogrammetry

CHNT Reference:
Stefano Bertocci et al. 2018. The Kyrenia Castle, an Approach to Digital Documentation in the Cyprus Island.

INTRODUCTION

The Mediterranean area is undoubtedly rich of built heritage masterpieces, evident traces of human presences populate the territory since the time of the beginning of humanity [Blake and Knapp 2008], it offers an impressive view of architectures combined with the natural landscape.

The coasts, especially, present a rich set of ports, harbors [Franco 1996], fortifications and fortified towns, many of them developed from the XIII century, then reorganized in a significant way all along the XV and XVI centuries [Rodriguez-Navarro 2015; Verdiani 2016; Iribarren 2017; Avilés 2017; Marotta and Spallone 2018].

Author's address: Stefano Bertocci, Dipartimento di Architettura, Università degli Studi di Firenze, Piazza Ghiberti, 27, 50121, Firenze (FI) Italy, E-mail: stefano.bertocci@unifi.it; Giorgio Verdiani, Dipartimento di Architettura, Università degli Studi di Firenze, via della Mattonaia, 8, 50121, Firenze (FI) Italy, E-mail: giorgio.verdiani@unifi.it; Alessandro Camiz, Özyeğin Üniversitesi, Mimarlık Bölümü, Nisantepe Mah. Orman Sok. No:34-36, 34794, Çekmeköy/Istanbul, Turkey, E-mail: alessandro.camiz@ozyegin.edu.tr; Zeynep Ceylanli, Department of Interior Architecture & Environmental Design, Özyeğin University,Nisantepe Mah. Orman Sok. No:34-36, 34794, Çekmeköy/Istanbul, Turkey, E-mail: zeynep.ceylanli@ozyegin.edu.tr; Müge Şevketoğlu, Cyprus International University, Center for Archaeology, Cultural Heritage and Conservation, Haspolat 99040, Nicosia, Cyprus.

In recent times this well-known heritage entered a high-risk phase: the wrong restorations, the lack of proper culture, the minimal resources, the uncontrolled, speculative urban development, and the climate change [Sabbioni et al. 2008] caused dangerous condition for the fortified heritage.

From this perspective, beyond any strategy or intervention plan, the creation of proper culture and knowledge in students and professionals working in the field of architecture and cultural heritage is a priority and a task that may improve the approach to such a built patrimony. At the same time, the use of digital survey has proved to be an excellent way of documenting and later investigating and developing a project about built heritage.

These digital tools are nowadays more affordable, both in terms of costs and complexity of use. Many international experiences show how an intervention based on 3D Laser Scanner and additionally contemporary photogrammetry may allow to “bring at home” a whole large architecture and then post-process the data legitimately for articulated aims [Bertocci et al. 2014; Verdiani 2017; Guidi et al. 2009].

In the will of giving a contribution in preserving and creating a possible future to the fortified heritage, the organization of international workshops, mixing students, tutors and professors from different provenances, is a great opportunity to bring on proper dissemination and knowledge about how operating. [Camiz 2018]

A CASTLE THROUGH TIME

The number of castles along the Mediterranean coast is very large; together with the system of towers and minor fortifications they created a network for inspecting and controlling the movement of ships and people along and from the sea. In specific cases, they were simply keeping and protecting a waterway or a port.

In the case of the Kyrenia Castle, there is clearly a very articulated transformation through time, making the castle evolving accordingly to the evolution of weaponry and its passing by very different owners [Camiz et al. 2016; 2017].

The Kyrenia Castle represents three distinct periods of architectural development, as the techniques of warfare advanced from bows and arrows to the invention of gunpowder and cannons. Kyrenia Castle is one of the best examples to trace the evolution of medieval military castles in the region. The three periods traceable in the architecture of the fortifications are: Byzantine (330-1192 AD), Lusignan (1192-1472 AD) and Venetian (1472-1570 AD) [Enlart 1899]. The special position, with its strategic and practical importance, seems to be confirmed by the archaeological evidence besides the castle, Roman mosaics and Roman catacombs suggest the presence of earlier settlements dated about the 4th century AD.

The “Kyrenia Shipwreck”, the common name used to indicate the important finding of a ship from the 4th century BC in the waters in front of Kyrenia [Katzev 1981], also supports the idea about the presence of a busy port town. However, there is no evidence of a Roman military castle. This important relic is nowadays preserved inside the castle museum [Katzev 2008].

Today the castle, with its round towers, solidly built curtain walls, gun ports with smoke chimneys, and ramparts, represents one of the best architectural examples of the Venetian military architecture. Inside the castle in still well recognizable conditions there are prison cells, accommodation, and water cisterns created to provide support in case of siege. The drawbridge over a moat was the only way to access the castle. In the harbor remains of a chain tower are still in place; this was used to control incoming unwanted ships.

The gun ports facing the land are worth an explanation, their position comes from the fact that the attack was expected not only from the sea. Thus, even with such a series of defensive solutions, in 1571, Kyrenia Castle surrendered to the Ottoman army without firing a single shot [Hill 1948].

The Lusignan period castle entrance is visible after the end of the Venetian entrance rampart. The castle tower with its larger cut stones and coat of arms above the gate (placed during the British period) stands out from the Venetian period masonry work. The squared tower entrance of the Lusignan castle gate also had a portcullis. After the entrance a short tunnel suddenly turns left, this is a defence system in case the castle door gets broken, turning a blind corner and limiting the number of enemies to pass by and giving a better chance in pushing them back.

The North East tower of the Kyrenia Castle is still an intact Lusignan "horseshoe-shaped" tower with angled footing and loopholes for firing longbows [Jeffery 1935]. The Lusignans built the battlements for first, later the Venetians improved them, and so today they can be seen on the northern curtain wall. During this time, an enemy attack would

have used catapults instead of cannons. Ballista, crossbow, swords, and arrows were the most common artillery. Lusignan castle also had the Donjon or keep, which is today still partially visible and included in the museum exhibition. In its rooms King Peter's pregnant mistress was supposedly imprisoned by his jealous wife.

During the Lusignan period, the Kyrenia town where townsfolk resided and traded was a fortified town with its own towers acting as part of the castle fortification which was further enhanced by the Venetians and went out of use during the Ottoman period [Petre 2010].

The Byzantine castle is the first "castle" evidence in Kyrenia and its own remains, although fragmentary, can yet be traced. The main and prominent architecture from the Byzantine period is the chapel of St. George; originally built outside the Byzantine castle (and later outside Lusignan period castle). Venetians however, built their north-west tower enveloping it within the castle.

All the castle's stones were extracted from a nearby stone quarry named Chrysokava. The area was also used as an early Byzantine worship place.

THE STRUCTURE OF THE WORKSHOP

With the workshop in Girne/Kyrenia, "Reading and Designing the Kyrenia Castle" held in May 2018, an articulated group of participants from 30 different countries has faced the large Castle of Kyrenia. 56 students, 15 tutors, and 10 professors had the opportunity of considering this large castle from the point of view of the documentation, diagnosis, design and hypothesis of reuse and enhancement of its monumental apparatus. The approach to the subject was divided into three main tasks: the gathering of historical documentation, both from bibliographic sources and reading the evidences on site, the digital survey of the building with a specific attention to the museum areas, and the design intervention on the museum areas [Camiz, et al. 2018].

The aim of the workshop, coordinated with the Municipality of Girne and the Department of Antiquities and Museums, was to acquire data for the digital survey of the Castle and then to design a new archaeological museum inside the castle. For this survey time was extremely important, while the huge size of the building and the need to operate, teach and prepare/follow the post-processing and the preparation of the drawings/products coming from each scanning day was quite difficult. But it was possible to fix it in the mere time of one week.

The result was accomplished adopting an integrated survey, mixing the coverage from lasergrammetry with photogrammetry survey based on different sources; this allowed defining a quite complete and well exploitable coverage of the whole castle. The different teams collected a full 3D laser scanner survey of the central court and of its surroundings, a large set of aerial photogrammetric pictures by flying a small UAV, thousands of terrestrial hi-resolution photographs, and a 3D eye complete imagery of the castle. The team of professors and tutors processed a part of the data collected on site during the workshop for teaching purposes.

Within the different activities brought on, one team documented with photographs and drawings the different types of masonries present in the castle for restoration purposes [Farre et al. 2019] and another team documented with terrestrial digital photogrammetric techniques some of the archaeological fragments in the castle [Attenni et al. 2019].

Exploiting these bases, the design teams proposed different solutions for a new exhibition area for the Kyrenia Ship relic and redesigned the showcases inside the existing museum to exhibit the collection of artefacts found during the underwater archaeological search for the Kyrenia Shipwreck. Hopefully, it would be very useful to acquire further funding for such a research project based for now only on the participants' goodwill, the possibility to move this museum to a next condition, emerged quite clearly from the work of the design group, a challenge that may found in the Kyrenia Castle a subject of great potential.

LASERGRAMMETRY

Since the very first planning of the workshop, it was decided to have a 3D Laser Scanner survey as the central element of all the measurement interventions. This choice was done because of some fundamental aspects: the 3D Laser Scanner is a fully trustable procedure, its use is easy to teach (and learn), the operative range of measurement and the many quality/density features combinations allow covering very large buildings in hours. The set of software to manage and move the point cloud datasets from visualization to CAD integration are easily accessible and

nowadays quite simple in their basic functions (so once again well suitable for teaching them in the short time of a workshop). Last but not least, the team of professors and tutors participating in the workshop was well experienced in using these tools and in planning operations in a timely manner.

The 3D laser scanner in use for this survey was a Zöller-Froelich Z+F Imager 5006h a phase-shift laser scanner capable to gather points at a distance up to 80 meters with an accuracy of about two millimeters on normal reflective materials. In the survey work of the Kyrenia Castle, for all the scans it was preferred to use settings with a density of points in "middle" mode (in this survey work this setting created single point clouds up to 9 million points) or "high" mode (in this survey work this setting created single point clouds up to 19 million points) and with an accuracy mostly set to "high" (with a redundancy of five for each measured point). In this way, each scan station asked about three to six minutes, plus the positioning times. Because of the quite high level of details and the possibility to have always articulated shapes with well recognizable characteristics, the use of targets to simplify and improve the alignment procedures was reduced to a minimal, using mostly paper "black and white" checkerboard targets. A logic of "reduction" of the occlusion spaces [Bini and Bertocci 2012] and of "support" to the following automatisms in point-cloud alignments [Pomerleau et al. 2015], guided the planning of the survey strategy. In this way, it was possible to have short post processing times and fully descriptive results. The lasergrammetry survey covered the part of the castle from the main entrance up to the central court along the main passage and from there to the museum areas, the inner part of the northern tower, all the higher passages and the area of the Church. In five days, 257 scan stations were completed, gathering about 2.5 billion of points.

The needs of the workshop guided the post-processing strategy, starting from the second day of survey, one operator began to treat the datasets, checking them and bringing the alignment of each scan into a unique point cloud. In this way, each day of activity produced a single point cloud, furthermore treated by one of the groups of students. The area focusing of the groups was all around the museum area and the central court. So the survey work started from there and moved around for the first three days. The last two days of survey were mostly dedicated to sectors out of the planning/re-design studies, like the top parts with passages and the church.

The software in use for the post-processing of the 3D Laser Scanner data were *Autodesk Recap*[1] and *Bentley Pointools 8Vi*[2], two very practical tools, with *Recap* capable to accept directly the ZFS files from the Z+F unit, process them in fast, automatic (and easy to teach) mode and implement the point cloud data into other *Autodesk* software. Following the aligned point cloud was the base to produce some very basic references for the students group: vertical and horizontal sections, fronts, plan views, orthographic and perspective views of the castle. The views were selected accordingly to descriptive needs and following specific questions from the students and tutors. After the definition of the views, most of the time, the drawing was extracted in raster image mode, using the simplest solution for producing classic 2D drawings. All the 3D and advanced modelling were postponed for the researches foreseen as following steps of the workshop.

TERRESTRIAL PHOTOGRAMMETRY

In the last ten years, the renovation of photogrammetry has brought incredible advantages in all the disciplines. Nowadays the evolution of these tools is undoubtedly a great opportunity for any built heritage documentation. The growth in the use of these tools is evident and more and more the possibility of integration with GPS and 3D laser scanner data makes the use of photogrammetry strategic and efficient. The use of different dataset (3DLS, GPS, Images) is little by little moving to full integration, leaving the separation of tools/kind of surveys [Guidi 2014] like a past condition. The fast operations, good results, creating a model become as simple as taking pictures, for most of the students at the first use of this solution, the use of software based on SfM/IM procedures [Guidi and Gonizzi 2014] may look so simple and intuitive to appear like a kind of magic.

The automatization of the photogrammetry processing and the almost immediate generation of 3D models create sometimes the conditions for operating in a sort of "black box". On one side the pictures enter and on the other the textured 3D model comes out. It looks like the renewed photogrammetry has inverted the satirical aphorism of Ambrose Bierce when in his "Devil's Dictionary" he writes about the word "Picture":

> *"A representation in two dimensions of something wearisome in three".* [Bierce 1980]

[1] https://www.autodesk.com/products/recap/overview
[2] https://www.bentley.com/it/products/product-line/reality-modeling-software/bentley-pointools

Thus, it is clear that most of the issue about the quality of what is produced depends on the quality of the pictures. So, becoming a good photographer, at least from a technical point of view, with clear knowledge about photographic aspects and how they may affect the results from photogrammetry, is the most relevant step any student may take to start using conscientiously a camera to produce 3D models. Keeping the students out of this understanding is most of the case a poor choice.

The workshop had various photogrammetric activities, in many of them, the students were called to use and to get better experienced with their own cameras, while, at the same time, a set of professional pictures were taken by tutors and/or professors to create a solid completion of the digital documentation of the castle.

The photogrammetric works were divided by subjects and tools: one about all the external front of the Castle (using both a Nikon D800e full frame, 36.3 Mp DSLR with a 24-120 mm F4 Nikkor zoom lens and a 3D Eye kit with Sony Cyber-shot DSC-QX30 20.1 Mp camera, 10 meters pole and remote control); one about the relic of the ship in the Shipwreck room; one about the Graffiti in the Shipwreck room [Bertocci et al. 2019]; one about the church [Volzone et al. 2019], these three conducted using only the Nikon D800e with the Nikkor 24-120 mm F4 and a Micro-Nikkor 60 mm F 2.8; one about the single fragments around the main court, developed with various cameras [Attenni et al. 2019]. Moreover, some groups of students experimented the photogrammetry shooting and processing on some front of the central court, using their own equipment.

The photogrammetry processing was done partially in place, but most of all the accurate and final processing was postponed to the following phases. The problem to operate in place was connected mainly to the calculation time and the missing of a robust Internet connection. The first issue was something not possible to solve in the short time of the workshop, while the second issue was stopping any intention about uploading the pictures to some online service like the one provided by Autodesk Recap. Most of the photogrammetric processing was done using *Agisoft Photoscan*[3], using a couple of well performant notebooks. Some testing using Reality Capture were done to allow the participant to see the different results, the computing times, the specific differences in the workflow from picture to the final 3D model.

The students got instructions about how to work correctly for terrestrial photogrammetry, details about their cameras and about the tools in use in the workshop (the characteristics and benefits of a professional high-resolution DSLR and of the 3D Eye kit). They got all the information about how to perform basic treatments of their images and 3D models to enhance the result, without going too much in details about an advanced solution for pre-processing of the pictures [Gaiani et al. 2016] and post-processing of the 3D models [Verdiani 2011].

AERIAL PHOTOGRAMMETRY

Taking pictures from the air is one of the most common need (and dream) in archaeological and in general in the external survey, the last years made it quite a common task in any well-structured intervention.

The easy access to UAV technologies and the marketing of more and more safe and simplified systems available “on the shelves” made possible to anyone the use of a “flying camera” [Gilli and Gilli 2016]. It is worth to say that such a condition meets the need of regulations and rules, so, the actual conditions for using this global innovation must accomplish to local and specific rules, authorizations and laws that are expected to be well known by the drone operators [Franke 2014].

In the case of the Kyrenia Castle, having a flight with a UAV unit was a great contribution in terms of completion and integration of the digital survey. Using a DJI Spark unit, equipped with a 12 Mp camera, the series of flights produced a sub-selection of 1303 usable shots, covering all the top parts of the walls and completing a massive, but well detailed 3D model of all the external parts of the castle and its near surroundings.

The operators started all the main flights from the central courtyard and from the top of the walls, some secondary flights were taken from the streets around the castle. The participants to the workshop were able to assist the operation and post-process various image sets taken from the UAV, obviously, it was not possible to have a “hands-on” experience in flight mode, but they got a well-detailed description of all the procedures and operational conditions.

[3] https://www.agisoft.com/

DESIGN PROPOSAL

Three design teams worked in close contact with the lasergrammetry team since they provided the necessary cloud datasets of the whole structure to be transferred to CAD programs during the design process.

What had been given as a design problem was to re-evaluate the spatial characteristics of the castle and the existing museum section and come up with a proposal for an archaeological museum entirely dedicated to the Kyrenia Shipwreck [Katzev 1981], which holds an important place in the history of underwater archaeology [Katzev 2008].

All the teams approached the castle museum in different angles: the design program was set either comprehensively from the main entrance of the castle to the showcases for the artefacts with a separate temporary structure for the shipwreck or focused on the existing museum section to create an affordable real-time solution as a response to the request of the museum administration.

Both approaches acknowledged the changing characteristics of museums in terms of pedagogy, cultural production, economic appraisal, and social interaction where the museum is designed in consideration with the

> *"…bodily, sensory and affective impacts of spaces and objects on visitors"*. [Tzortzi 2017, p. 495]

The design intervention was not conducted by the tutors and the students merely as a museum design exercise, but the means of understanding and promoting a cultural heritage was also examined throughout the workshop. One of the groups chose to introduce a novel architectural extension that goes through and constructs the whole visitor path.

The group working on the showcases highlighted the small artefacts that were revealed from the Kyrenia Shipwreck, depicting a physical attribution to what the casings exhibit specifically. Yet, another group defined the existing problems of the current exhibition and the physical inadequacies of the Kyrenia Castle Museum and came up with a practical yet inclusive design proposal, where the sixth one of the consequent rooms on the northeast side of the inner courtyard was to be rebuilt with a contemporary construction material to house the shipwreck [Ceylanlı et al. 2019]. The design proposals were brought on to a certain point where the administrative organs could have a perspective plan of executing a well-rounded museum for the sake of the castle, the shipwreck and the city of Girne.

CONCLUSIONS

The Kyrenia Castle workshop has been the occasion to establish an operative base of knowledge and to gather a significant amount of data about a Castle that represents a challenging monument in the Mediterranean scenario.

The first digitalization of this fortification is ought to be the starting point of a series of studies. This paper, following the poster brought in the CHNT/VH conference in Vienna in November 2018, presents the roadmap about the post-processing of the digital resources produced in the castle in the days of the workshop (Fig. 6).

If the workshop was the moment to disseminate and strictly collaborate, the following phases are the moments for reflections, in-depth researches, more accurate calculations, experiment and testing with different solutions.

Writing this research allows the development of a series of papers, describing the various activities and the specific experience and investigations centered on the Kyrenia Castle, as well as a series of master's and specialization theses about the development of an HBIM [Brusaporci 2015] of some part of the castle, the proposals for a new museum assets, an intervention plan about a set of strategic starting restorations and new approaches to the presentation of some valuable items inside the castle, like the Kyrenia Ship and the various Graffiti representing harbors, ships and boats.

The historical value of the subject and the technically advanced intervention, mixed with professional and academic competencies has brought to a high-quality teaching moment, even in the variety of proveniences, interests, approaches, the people involved in this experience have found a moment of measuring themselves with the importance of the monument, with his story.

A moment where Cultural Heritage and New Technologies have really found a common ground!

Fig. 1. View of the Kyrenia Castle from the harbour (poto: Neuwieser)

Fig. 2. A group of participants to the workshop working with the 3D Eye unit

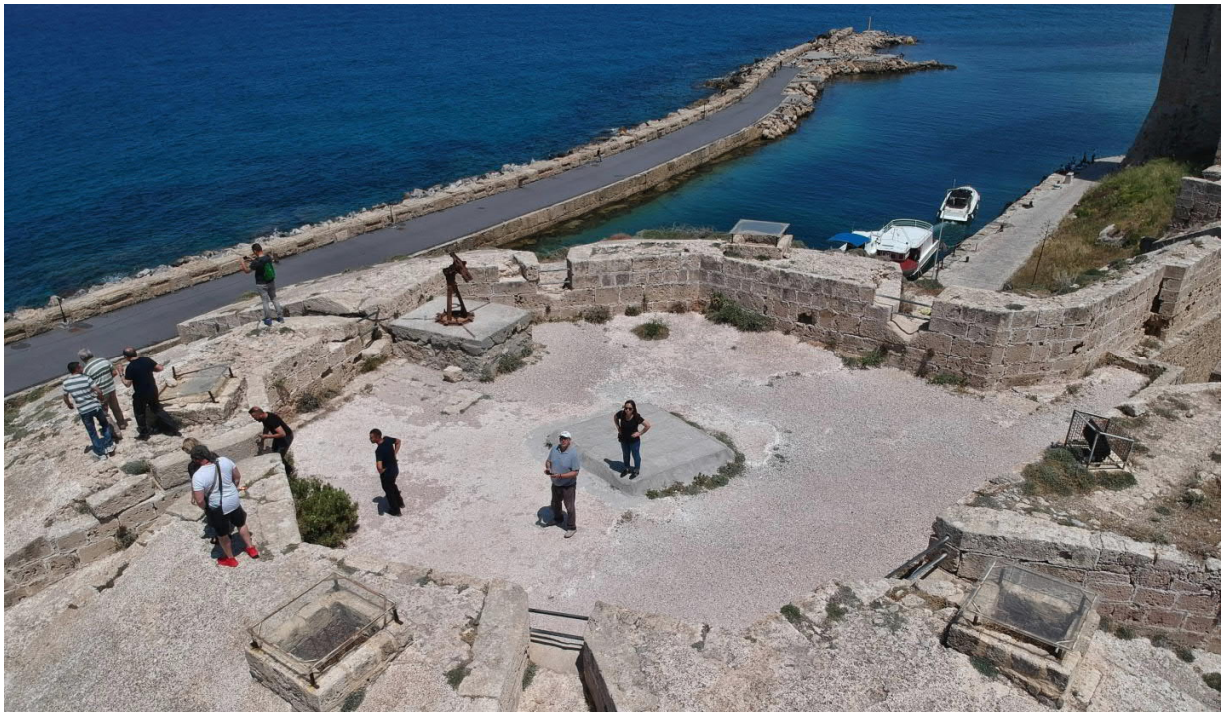


Fig. 3. Operations with the drone on the walls of the Kyrenia Castle

Fig. 4. The aligned point-cloud from the 3D Laser Scanner survey in Autodesk Recap

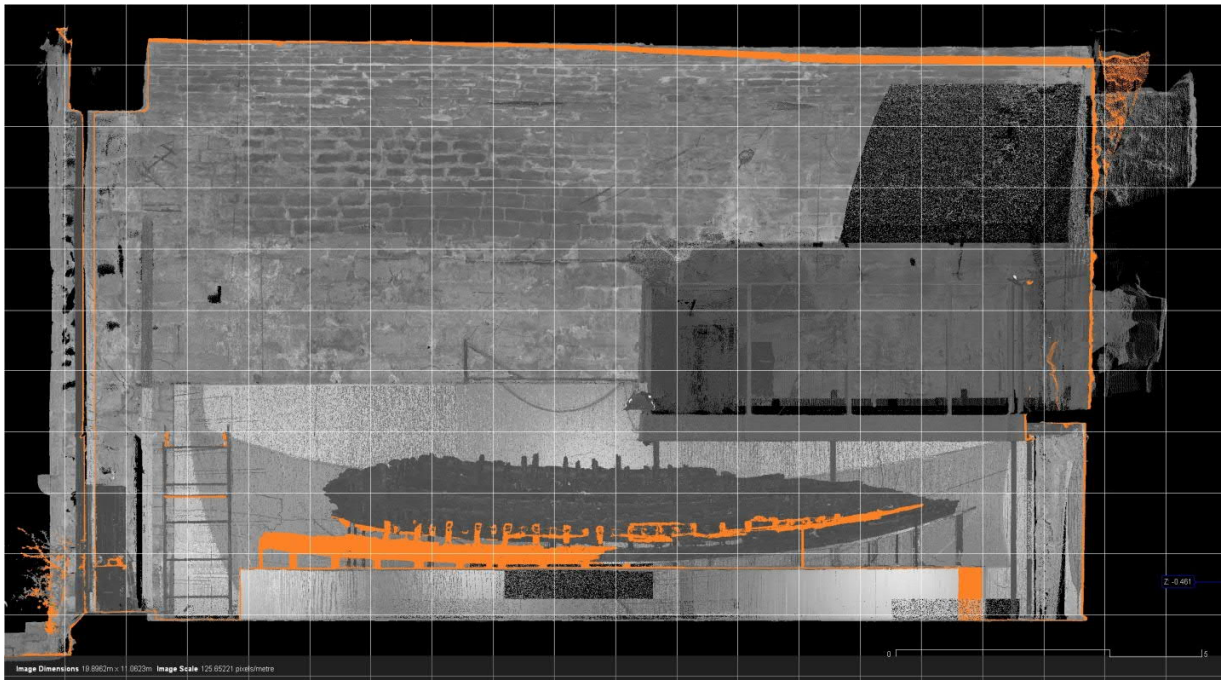


Fig. 5. Sections and plan views from the aligned point cloud

Fig. 6. The poster (original in UNI A0 format) as presented in occasion of the Cultural Heritage and New Technology / Visual Heritage Conference, Vienna, 2018

ACKNOWLEDGEMENTS

The workshop “Reading and Designing the Kyrenia Castle” is one the results of the ongoing scientific collaboration between Girne American University (Department of Interior Architecture) with the Department of Architecture of the University of Florence and the Department of Interior Architecture of Özyeğin University. The workshop took place between the 6th and the 13th of May 2018 at Girne American University, Cyprus Island. We would like to thank all the members of the scientific committee and in particular Giovanni Carbonara, Roberto Secchi, Kutsal Öztürk, Orhan Hacıhasanoğlu, Stefano Bertocci, Carlo Bianchini and Daniela Esposito, for the collaborative support. Within the organizing committee, a special acknowledgement must be given to Pembe Özen and to the entire Department of Antiquities and Museums for continuous participation. Within Girne American University, Faculty of Architecture, Design and Fine Arts, which made this workshop possible and supported it economically, special thanks must be given to Valentina Donà, and Carmelo Cascino.

REFERENCES

Martina Attenni, Marika Griffo, Almira Khafizova, and Sofia Menconero. 2019. A Workflow for Fast 3D Documentation, in Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018. CHNT 23, 2018 (Vienna 2019).

Ángel Benigno González Avilés (Editor). 2017. Defensive Architecture of the Mediterranean XV to XVIII centuries - Volume 6. Publicacions Universitat D’Alacant.

Stefano Bertocci, Giorgio Verdiani, and Muge Sevketoglu. 2019. Graffiti Photogrammetry, Extracting the Signs from the Walls of the Kyrenia Castle, in Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018. Vienna.CHNT 23, 2018 (Vienna 2019).

Stefano Bertocci, Sandro Parrinello, and Rebeka Vital. 2014. Masada Notebooks. Report of the research project, Iiriti editore, Italia.

Ambrose Bierce. 1980. The Devil's Dictionary, Library of Alexandria.

Marco Bini and Stefano Bertocci. 2012. Manuale di rilievo architettonico e urbano, CittàStudi, Torino.

Emma Blake and A. Bernard Knapp. 2008. The Archaeology of Mediterranean Prehistory, Wiley Blackwell Studies in Global Archaeology, John Wiley & Sons.

Stefano Brusaporci. 2015. *Handbook of research on emerging digital tools for architectural surveying, modeling, and representation*, Advances in Geospatial Technologies: IGI Global.

Alessandro Camiz, Giorgio Verdiani, and Zeynep Ceylanli. 2018. International workshop: reading and designing the Kyrenia castle. in Sandro Bertocci. ed., *Conference Proceedings of Symposium of representation scientific area for development of multidisciplinary international programs.* Florence: DIDApress, pp. 264-298.

Alessandro Camiz. 2018. History, techniques and restoration in the island of Cyprus. in Rosa Anna Genovese ed. *Historic Cities and Heritage as the Hubs of Social and Cultural Integration, Sustainability and Innovative Technologies*. Napoli: Giannini Editore. pp. 315-338.

Alessandro Camiz, Marika Griffo, Seda Baydur, F.T. Fidan, and Siepan Khalil. 2017. The round corner tower of Kyrenia's city walls (1211-1232). in A.B. González Avilés, ed. *Defensive Architecture of the Mediterranean XV to XVIII centuries*, Alicante: Editorial Publicacions Universitat D’alacant. pp. 55-62.

Alessandro Camiz, Siepan Khalil, Sara Cansu Demir, and Hassina Nafa. 2016. The Venetian defense of the Mediterranean: the Kyrenia Castle, Cyprus (1540-1544). in Giorgio Verdiani ed. *Defensive architecture of the Mediterranean. XV to XVIII Centuries*. vol. 3, Firenze: DIDApress. 371-378.

Zeynep Ceylanlı, Pembe Özen, Ezgi Çiçek, and Pelin Arslan. 2019. Evolving from castle to virtual space: the case of Kyrenia Shipwreck Museum, in Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018. CHNT 23, 2018 (Vienna 2019).

Camille Enlart. 1899. *L'art Gothique et la Renaissance en Chypre*. Paris: Ernest Leroux Éditeur.

Leopoldo Franco. 1996. Ancient Mediterranean harbours: a heritage to preserve, in Ocean & Coastal Management, Volume 30, Issues 2–3, Elsevier.

Ulrike Esther Franke. 2014. The global diffusion of unmanned aerial vehicles (UAVs), or "drones", in Precision Strike Warfare and International Intervention Strategic, Ethico-Legal and Decisional Implications, Mike Aaronson, Wali Aslam, Tom Dyson, Regina Rauxloh (Editors), Taylor and Francis.

Gabriele Farre, Emilia Valletta, and Zarif Ezdeşir. 2019. Letting a Wall Tell its Story: A Low-cost Interactive Proposal for Kyrenia Castle, Cyprus, in Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018. CHNT 23, 2018 (Vienna 2019).

Gabriele Guidi. 2014. Terrestrial optical active sensors – Theory & applications. In Stefano Campana & Fabio

Remondino, eds. *3D Recording and Modelling in Archaeology and Cultural Heritage-Theory and best practices*. Oxford: Archaeopress Publishers of British Archaeological, pp. 37–60.
Gabriele Guidi, Fabio Remondino, Michele Russo, F. Menna, A. Rizzi, and S. Ercoli. 2009. A Multi-Resolution methodology for the 3D modeling of large and complex archaeological areas, in *International Journal of Architectural Computing*, Vol. 7(1), pp. 39-55.
Gabriele Guidi and Sara Gonizzi. 2014. Image pre-processing for optimizing automated photogrammetry performances, in ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., 145-152. Volume II-5.
Marco Gaiani, Fabio Remondino, Fabrizio I. Apollonio, and Andrea Ballabeni. 2016. An Advanced Pre-Processing Pipeline to Improve Automated Photogrammetric Reconstructions of Architectural Scenes, in *Remote Sensing* 2016, 8, 178, MDPI.
Andrea Gilli and Mauro Gilli. 2016. The diffusion of drone warfare? industrial, organizational, and infrastructural constraints, in *Security Studies* 25, no. 1, pp. 50–84.
Víctor Echarri Iribarren (Ed). 2017. Defensive Architecture of the Mediterranean XV to XVIII centuries - Volume 5. Publicacions Universitat D'alacant.
George Jeffery. 1935. A *description of the Monuments of Cyprus*. Nicosia: William James Archer.
George Hill. 1948. *A History of Cyprus. Volume 2: The Frankish Period 1192-1432*, Cambridge University Press, Cambridge.
Michael Katzev. 1981. The Reconstruction of the Kyrenia Ship, 1972-1975, in *National Geographic Society Research Reports*, volume 13. pp. 315-328.
Susan Katzev. 2008. The Kyrenia Ship: Her Recent Journey, in *Near Eastern Archaeology*, Vol. 71, No. 1/2. pp. 76-81.
Anna Marotta and Roberta Spallone (Eds). 2018. Defensive Architecture of the Mediterranean XV to XVIII centuries, vol. 8, Politecnico di Torino, Italy
James Scott Petre. 2010. Crusader castles of Cyprus: The fortifications of Cyprus under the Lusignans of 1191-1489. PhD Thesis, Cardiff University.
François Pomerleau, Francis Colas, and Roland Siegwart. 2015. "A Review of Point Cloud Registration Algorithms for Mobile Robotics", Foundations and Trends® in Robotics: Vol. 4: No. 1, pp 1-104.
Pablo Rodriguez-Navarro (Ed). 2016. Defensive Architecture of the Mediterranean XV to XVIII centuries, vol. 1 Editorial Universitat Politècnica de València, Spain.
Rolando Volzone, Dinâmia' Cet-iul, Matteo Bigongiari, and Federico Cioli. 2019. The Church of St. George in the Kyrenia Castle in the North of the Island of Cyprus, Bringing out the Shape of Architecture, in *Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018, Vienna 2019.*
Cristina Sabbioni, May Cassar, Peter Brimblecombe, and Roger-Alexandre Lefevre. 2008. *Vulnerability of Cultural Heritage to Climate Change, Report*, EUR-OPA Major Hazard Agreement, Council of Europe, Strasbourg.
Kali Tzortzi. 2017. Museum architectures for embodied experience, in *Museum Management and Curatorship*, 32:5, pp. 491-508. DOI: 10.1080/09647775.2017.1367258
Giorgio Verdiani (Ed). 2011. *Il ritorno all'immagine, nuove procedure image based per il Cultural Heritage.* Lulu.com.
Giorgio Verdiani (Ed). 2016. Defensive Architecture of the Mediterranean XV to XVIII centuries, vol. 3. Firenze: DIDA Press, Italy.
Giorgio Verdiani. 2017. Fortifications and documentation: the case of Fortezza Vecchia in Livorno. State of the digital survey 2017, in Defensive Architecture of the Mediterranean XV to XVIII centuries, Alicante, Spain, Editorial Publicacions Universitat D'alacant, vol. 6, pp. 311-318.

Some videoclip about some phases of the workshop can be seen in a playlist at the following link: International Survey and Design Seminar & Workshop: Reading and designing the Kyrenia Castle, 3D Laser Scanner, Graffiti Photogrammetry, Aerial Photogrammetry.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz

Mapping Heritage in Vienna

BARBARA BUCHER and ANDREAS KOLBITSCH, Technische Universität Wien, Austria

Vienna's 1st municipal district is an area dense with built heritage. A public map created in Google Maps shows the location of heritage building protection. It combines open data provided by the City of Vienna and the Federal Monuments Authority. The map has two functions: first, the map holds information on the 669 individual buildings that are protected according to the Austrian Monuments Law, providing information on the individually protected buildings in five layers. Among these layers, one shows the location of these buildings without further discrimination, while another layer shows whether buildings are protected by legal presumption or by decree. Additional layers show building characteristics such as the number of storeys, original roofs and use. By clicking on a building in any layer, additional building information appears on the left-hand side of the browser window, including alternate addresses, year of construction and architect. The second function of the map is to show different legal protection areas, such as the UNESCO World Heritage site "Historic City Centre of Vienna" and the "Protected Zones" according to the Building Code for Vienna. Viewers can choose between three layers visualizing the core and buffer zones of the World Heritage site, protected zones and the ensemble "Vienna City Centre". By selecting multiple layers at once, viewers can see where areas overlap and buildings therefore enjoy triple legal protection, but can also instantly locate gaps where this is not the case. The map visualises the complex legal construct that protects the built heritage in Vienna. It allows viewers to easily identify areas with dense legal protection and in addition provides easily accessible information on listed buildings.

Key words:
Built heritage, map, heritage policy, open data.

CHNT Reference:
Barbara Bucher and Andreas Kolbitsch. 2018. Mapping Heritage in Vienna.

INTRODUCTION

Vienna's 1st municipal district is an urban centre rich in built heritage. Located at the core of today's metropolis, the 1st district's built remnants are testament to the continuing development of urban fabric for more than two millennia. Despite extensive change as well as damage inflicted during World War II, today approximately 84% of buildings are more than 100 years old (see Fig. 1).

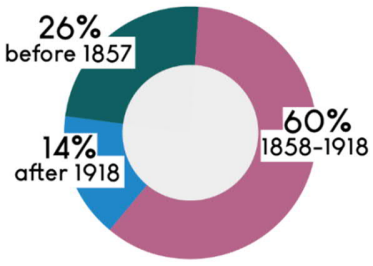


Fig. 1. Percentage of buildings by construction date in Vienna's 1st district

Authors addresses: Barbara Bucher, Institute of Construction, Structural Dynamics and Building Technology, Technische Universität Wien, Karlsplatz 13, 1040 Vienna, Austria; email: barbara.bucher@tuwien.ac.at; Andreas Kolbitsch, Institute of Construction, Structural Dynamics and Building Technology, Technische Universität Wien, Karlsplatz 13, 1040 Vienna, Austria; andreas.kolbitsch@tuwien.ac.at.

During its development over 2000 years, Vienna evolved from a Celtic settlement to a Roman border town, to become the residency of the Emperors of the Roman Holy Empire and important cultural hub in the early modern period. In the middle of the 19th century Vienna was undergoing a phase of rapid growth, and the number of inhabitants rose steeply with ongoing industrialisation and subsequent urbanisation. The city centre's space was limited by the city walls and an adjacent area that was not to be built upon, the *Glacis*. The wall was originally designed to ward off potential invaders in the 17th and 18th century, but outgrew its usefulness as the need to expand and create housing soon outweighed the risk of an attack. In 1857 Emperor Franz Josef I. therefore decided for the city walls to be torn down and the Glacis area to be built upon, henceforth connecting the city centre with the surrounding districts [Franz Josef I. 1857].

The subsequent rush to construct on the newly liberated building space gave Vienna some of its most iconic buildings along the new semi-circular boulevard, the *Ringstraße*. While entire new neighbourhoods were built on the edge of the district, progress did not spare the old city centre's core. The demolition of the city walls allowed for new points of access to the centre, which in turn led to the redesign of whole streets – opening up axes through the district – and to older buildings being replaced by new ones.

Fortunately, Vienna's 1st district was only mildly damaged during World War II and few buildings had to be replaced or reconstructed. Even in the following decades, demolition of historic buildings and construction of modern structures was rare. The integrity of the historic building stock led to the city centre being inscribed on the UNESCO World Heritage List in 2001.

Despite the relatively recent inscription by UNESCO, the protection of cultural heritage has long been anchored in Austrian law. As propagated by Austrian art historian Alois Riegel at the beginning of the 20th century, a need to preserve a building's historic value was recognized. In 1923 the "Austrian Monuments Law" (DMSG) was introduced, which today still protects Austria's cultural heritage. The law defines cultural heritage as those assets whose preservation is in the public's interest.

The DMSG also stipulates that the "Federal Monuments Authority" (BDA) is tasked with the identification, listing and protection of cultural heritage. According to the DMSG any building with historical, artistic or other cultural significance must be protected if it is in the public's interest. This means that the BDA starts a process of evaluating whether this is the case. Once established, the listed status remains until it is revoked after a process initiated by application of the BDA itself. The listing status of a building is noted in the title register, and has significant limitations to building owners as any change within building substance requires permission by the BDA.

While the BDA also recognises ensembles as entities that can be protected, it is mainly concerned with the protection of individual object. Yet the functionality of a city works on a different scale and needs to consider larger entities, such as neighbourhoods and districts. In response to this demand for zonal protection, the City of Vienna introduced Schutzzonen (protected zones) in 1972, which are now legally stipulated in the Building Code for Vienna. Unlike the limitations of BDA listing, buildings within protected zones are only considered in terms of their appearance within the city scape. Proposed changes, however, need to be licensed by the city magistrate.

While change in the city is ongoing, Vienna's policy regarding cultural heritage management is also constantly developing and new issues may emerge and need to be addressed. New requirements in city planning may require the areas of protected zones to be widened but also reduced. A prominent example of this is the Heumarkt development projects.

As described above, there are three legal layers of heritage protection guarding Vienna's built heritage, each having different implications. The authors recognised the need to illustrate these layers in order to facilitate a unified understanding of heritage policy in Vienna, and to that end combined these in a readily accessible online map. This paper describes the process of how this interactive online map was created that visualises the location of built heritage.

The map is intended to facilitate the understanding of the extent of built heritage and listed buildings, as well as different parameters about them. The map provides viewers with the location of historic buildings which are protected according to the Austrian Monuments Law and also shows the extension of protection areas, such as the UNESCO "World Heritage" (WH) Site "Historic Centre of Vienna". The map can be used by interested members of the public, but also professionals working in the field of heritage policy and may be used to facilitate decision making in the future. The results of the map making process were presented as a poster at CHNT 23.

METHODOLOGY

The main goal was to create a map that can be viewed free of charge, is operating system and device independent, as well as user friendly. Google Maps was selected because it is a widely accepted standard, fulfils all previously mentioned criteria, and allows users to create custom maps without the need for additional software. While Google Maps is easy to use for those creating and viewing the map, it is somewhat limited in its function. There is no possibility for enhancing and customising the map through programming. Some viewers might require additional tools, such as adjusting the transparency of layers to create overlays. This is, unfortunately, not possible with this map.

The information included in the map is sourced from open data; the main task in creating the map was combining building data provided by the City of Vienna and the Federal Monuments Authority (BDA). Limited resources did not allow for all data to be cross-checked by the authors. The authors are aware that there is missing and faulty information, e.g. spelling inconsistencies, in the data sets, which were corrected when possible.

Two datasets were combined to create the first and mayor layer of the map "Denkmalschutz gesamt" (all listed buildings): The first dataset is the "Gebäudeinformation" [Stadt Wien 2017] provided by the City of Vienna, and includes around 1.500 buildings in the 1st district and contains additional information such as construction year and architect. The second dataset "Wien_2017" [Bundesdenkmalamt, 2017], provided by the BDA, is comprised of immovable heritage objects, including fountains, statues and tram stations in Vienna. Any objects in this dataset outside the 1st district and any objects that are not buildings were removed, resulting in 669 individual buildings considered for the base-layer of the map.

The 669 buildings identified in the BDA list were then matched to their corresponding entries in the dataset "Gebäudeinformation". Buildings may have several street addresses corresponding to entrances on more than one street, be they corner buildings or buildings that have a front and rear exit to different streets. Such alternate addresses were recorded in the map to ensure that viewers, who may not know all addresses of a specific building, can still find it on the map with the address they know.

In a next step, 669 polygons were drawn directly in Google Maps corresponding to the areas of the buildings on the BDA list. As the dataset "Gebäudeinformation" only includes point coordinates for each building, the "Baualtersplan Wien: innere Stadt" [Wehdorn et al. 2011] was consulted for establishing building borders. This hand-drawing of the building areas was necessary as the buildings delineated in Google Maps do not always correspond to the actual borders as established in the relevant BDA and City of Vienna documents.

The Google Maps base map was set to "light political", as this map includes only information on streets, building blocks, parks and rivers, while omitting most other, distracting information. Because it is less cluttered than the standard Google map, it helps viewers to focus on the essential information: the historic buildings. The language of the map is set to German, as the authors anticipate that most interested viewers will be German speakers.

One drawback of Google Maps is the limited ability to edit the polygon's additional information. As the aim of the map was to provide easy access to additional building information on BDA listed buildings, however, the software QGIS was used to combine spatial data of the polygons exported from Google Maps as KML files, with the building data as CSV files. A KML file created with QGIS was then imported back into Google Maps, thus displaying the relevant additional information directly in Google Maps.

When viewers select a polygon on the map, the following building information appears in a window on the left-hand side of the map: Name (identical to first street address), descript_2 (alternate street addresses), OBJECTID (ID in the dataset "Gebäudeinformation" by the City of Vienna), OBJECTID_B (ID in the dataset "Wien_2017" by BDA), STATUS (legal basis for listing), GESCH_ANZ (number of storeys), L_NUTZUNG (current use), BAUJAHR (year of construction), HA_NAME (house name), ARCHITEKT (architect), L_BAUTYP (building type), ORIG_PARZ (original allotment), ORIG_FASS (original façade), ORIG_KERN (original core), ORIG_FENST (original windows), ORIG_DACH (original roof).

RESULTS

The resulting map "Gebautes Erbe Wien 1010" contains ten layers. Eight of these were created to illustrate aspects of built heritage, one layer – "Bezirksgrenze I." – shows the district border, while one layer contains the Base map, which shows topography. Among the eight layers illustrating aspects of built heritage, five layers inform viewers on

individually listed buildings according to the DMSG: “Denkmalschutz gesamt” (all listed buildings), “Rechtliche Grundlage” (legal basis), “Geschoßanzahl” (number of storeys), “Dächer” (roofs) and “Nutzung” (use). These layers are to be viewed separately, one at a time.

The remaining three layers give information on protection areas: “Ensemble Wien Innere Stadt” (ensemble Vienna city centre), “Weltkulturerbe” (World Heritage) and “Keine Schutzzone” (not protection zone). These layers are to be viewed in combination with each other and in combination with “Denkmalschutz gesamt” to illustrate where protection areas overlap.

Individual building protection

The map layer “Denkmalschutz gesamt” shows 669 polygons representing individually listed buildings according to the DMSG, as found in the BDA dataset “Wien_2017”. The polygons are coloured in dark green, providing a strong contrast to the base map (see Fig. 2). When clicking on a polygon, additional building information appears on the left-hand side of the map.

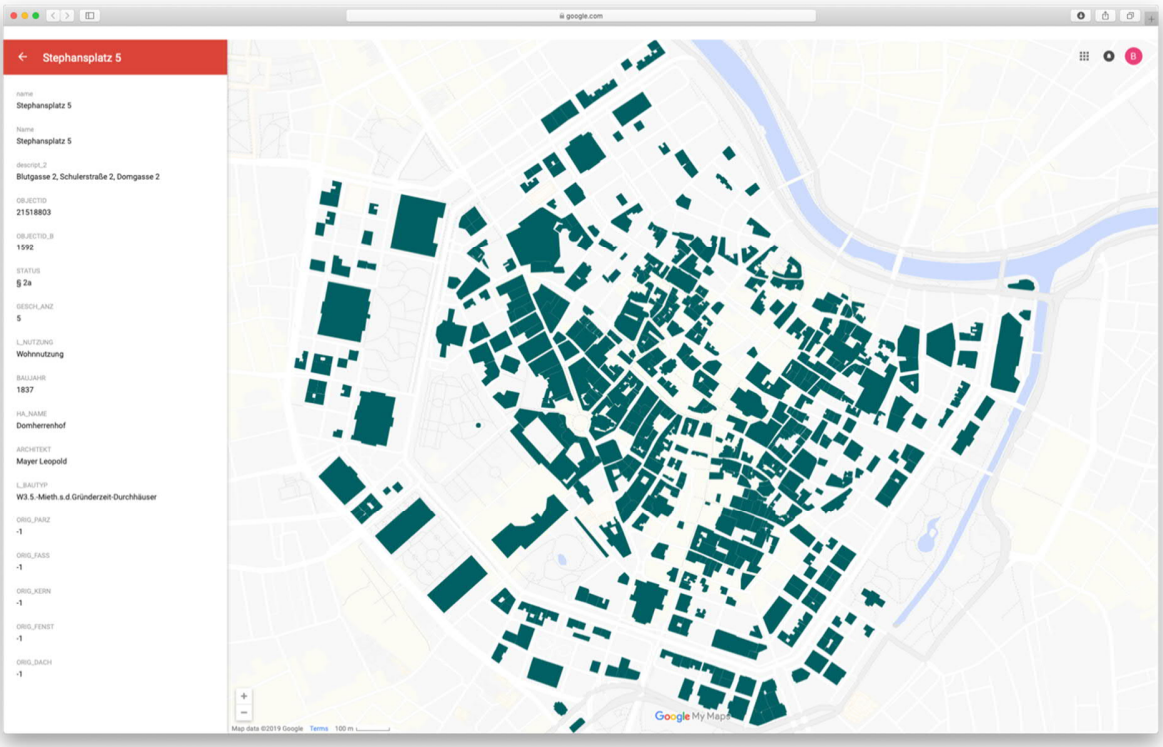


Fig. 2. Buildings on the BDA list (dark green) in Vienna’s 1st district, (on the left) building information for the selected polygon Stephansplatz 5 *(Map data © Google Maps)*

Listed buildings account for around 55 % of all buildings in the district and are fairly evenly distributed. Noticeable gaps of listed buildings in built-up areas are located just north of the very centre of the district, in the north-east corner towards the Danube canal and also further along downstream the Danube canal. The latter area was completely destroyed during World War II and later rebuilt, which may explain the lack of listed buildings. The large empty area east of the centre (see Fig. 2), on the other hand, is comprised of several parks and public squares.

Four additional layers highlight several aspects of building information of listed buildings. Fig. 3a shows the layer Rechtliche Grundlage, indicating the legal basis for BDA listing. Up until 2009, buildings that were majorly owned by public or religious insitutions were listed by legal presumption (light green polygons), while privately owned buildings were listed by decree (blue). Since 2009, listing can only follow a decree by the BDA. The spatial distribution of either legal basis is fairly even across the district.

Fig. 3b shows the layer “Geschoßanzahl” (number of storeys), in which polygons are coloured differently according to the number of storeys of the corresponding building. The majority of buildings, 558, consists of 4 to 6 storeys, the most common number of storeys is 5 (purple) with 264 buildings. Only 20 buildings have 7 storeys or more (green palette), and only 58 buildings have 3 storeys or less. For 33 of the buildings, no information on number of storeys was included in the data; these are mostly churches or theatres where different building parts have different numbers of storeys. The spatial distribution of numbers of storeys is fairly even.

Fig. 3c shows the layer “Dächer” (roofs), which illustrates whether buildings still have their original roof (red polygons) or whether their roof was replaced (dark blue polygons). There are 359 original roofs compared to 309 not-original ones (with only one building lacking this information in the data set), and their spatial distribution is even. As roofs are suceptible to damage over time, by fire or water, it is noteworthy that so many original roofs still exist.

Fig. 3d shows the layer “Nutzung” (use), where polygons are coloured according to the buildings’ current use. Light green polygons indicate commercial use and are located predominantly along the shopping streets, Kärnter Straße, Graben and also Opernring. Several large public institutions coloured in red can be found towards the east of the centre, clustered around the Imperial Palace complex. A slightly denser concentration of buildings with housing use, coloured in purple, can be found west of the centre.

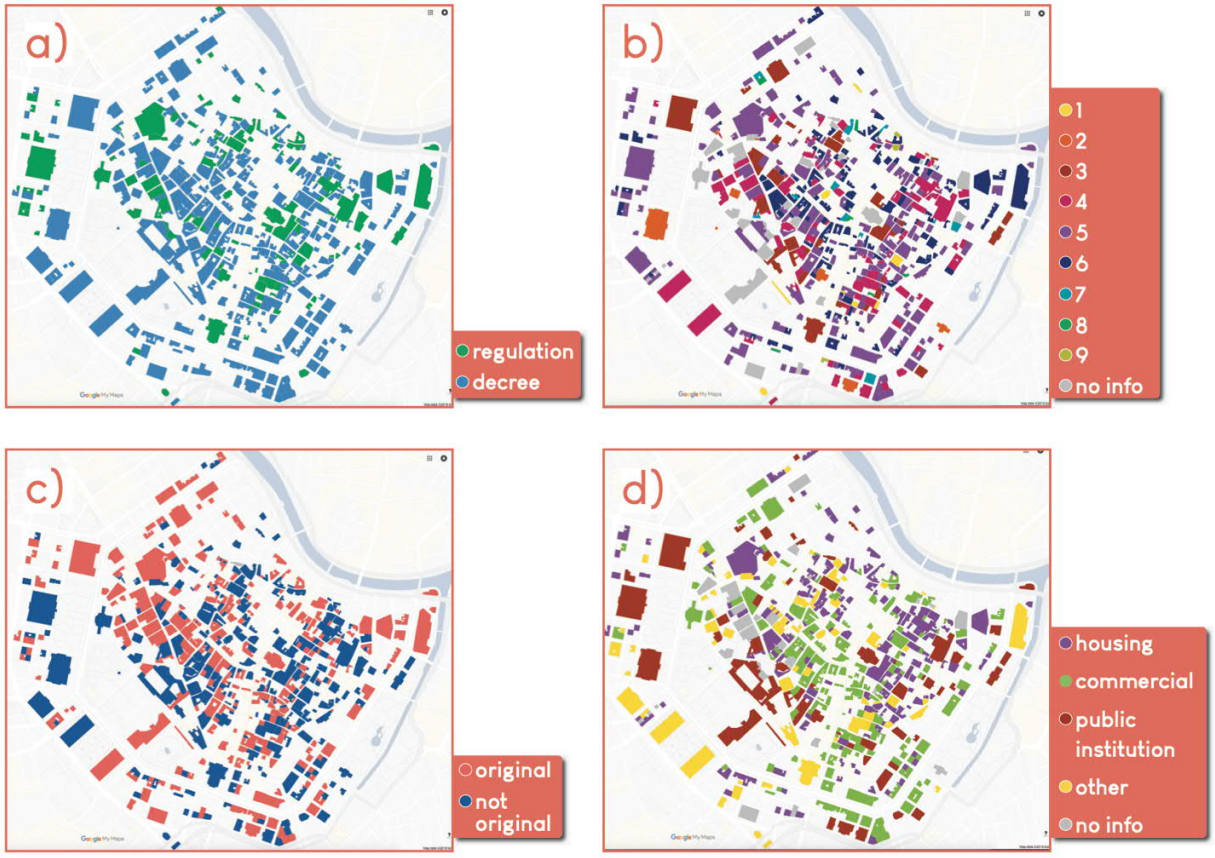


Fig. 3. Map layers: a) legal basis for BDA listing, b) number of storeys, c) original roof and d) type of use (Map data © Google Maps)

Protection areas

In addition to individually protected buildings, laws that concern built heritage in Vienna also define three legally distinct protection areas. These are included in the map in the following three separate layers: “Ensemble Wien Innere Stadt” (ensemble Vienna city centre), “Weltkulturerbe” (World Heritage) and “Schutzzone” (protected zone).

For easier legibility, the map also contains an additional layer which only contains the 1st district's border, which when selected, appears as a red line.

The first legal protection area is the "Ensemble Wien Innere Stadt" (ensemble Vienna city centre), its borders are defined by the BDA [Bundesdenkmalamt, n.d.] and its legal basis is the Austrian Monuments Law. In this layer, a green polygon shows the extent of the ensemble, which covers almost the entire 1st district. When combined with the layer Denkmalschutz gesamt (all listed buildings), see Fig. 4a, it can be seen that the area of the ensemble does not cover all of the 1st district's BDA listed buildings (dark green). Surprisingly, there are several listed buildings on the outer side of the Ringstraßen boulevard which are not part of the ensemble.

The second legal protection area is the UNESCO WH Site Historic City Centre of Vienna [Stadt Wien 2012]. The layer "Weltkulturerbe" (World Heritage) visualises the extent of the core (purple) and buffer zone (light pink). When this layer is selected together with the layer showing the BDA ensemble (Fig. 4b), viewers will notice a large overlapping area of the core zone and the ensemble (dark purple). Both protection areas exclude a small area along the Danube canal in the north-east of the district, where no individually listed buildings are located either.

The third legal protection area is the "Schutzzone" (protected zone) according to §7 of the Building Code for Vienna. It covers the entire 1st district, but does not fully correspond to the extent of the core zone of the WH site. In order to highlight these discrepancies, the layer "Keine Schutzzone" (no protection zone) was created. Here, light grey polygons correspond to the areas which are part of the WH site but not part of a protected zone. When selected together with the layer showing the WH site (Fig. 4c), viewers will notice several grey areas within the buffer zone, especially along the Danube channel. Two controversially discussed grey areas are located in the 3rd district, east of the centre: the area of the new train station Wien Mitte/Landstraße with adjacent high rise buildings in the puffer zone and the more recently excluded area of the Heumarkt development project within the core zone. While the former project was realised in the early 2000s despite concerns of its negative impact on the WH site, the latter project is still being fervently discussed.

Fig. 4. a) BDA ensemble (light green) individual buildings on BDA list (dark green), b) UNESCO WH site overlap with BDA ensemble (dark purple), c) areas within WH site not part of protected zone (light grey) (Map data © Google Maps)

CONCLUSION

This paper describes the process of how a map visualising the built heritage in Vienna's 1st district was created. The resulting map "Gebautes Erbe Wien 1010" is based completely on open data and is accessible online to anyone with the link[1]. The map provides interested viewers easy access to information on the location of individual buildings protected by the Austrian Monuments Law and building information collected by the City of Vienna. In addition, by adding layers to the map that illustrate different protection areas, it is possible to instantly see overlapping areas or gaps in zonal protection.

The combination of individual heritage buildings and zonal protection is unique to this map. Other maps, such as, for instance, the Kunstkataster Tirol [Land Tirol 2019] or Historic Wales [Historic Wales 2019] provide point locations of historic buildings, yet do not provide to information on protected zones. While the additional information on each asset in either map is very detailed, the maps are more difficult to use than the map of Vienna presented here.

[1] https://tinyurl.com/y7pesvwo

The map presented here is accessible on any web-enabled device. This means that interested users can reference the map while walking through the city centre. Unlike in other cities, none of Vienna's protection zones or individual listings is marked on the actual houses or street signs, hence interested visitors and locals alike cannot know whether a building is legally protected. The map provides a means to connect vital information of a building's legal status to its physical form.

Combining all layers of heritage policy, the map may also facilitate the understanding of the discourse on controversial building projects in the city centre. The map is designed to encourage interested viewers to enhance their knowledge of the historic building stock in Vienna, and may be used by interested members of the public, researchers and policy makers alike.

REFERENCES

Bundesdenkmalamt. n.d. Ensemble Wien I, Innere Stadt. Retrieved from: https://bda.gv.at/fileadmin/Dokumente/bda.gv.at/Publikationen/Denkmalverzeichnis/Wien/Wien_I_Innere_Stadt_Ensemble.pdf on 14.09.2017.

Bundesdenkmalamt. 2017. Denkmalliste Wien. Unbewegliche und archäologische Denkmale unter Denkmalschutz 2017. Retrieved from: https://bda.gv.at/de/denkmalverzeichnis/ on 14.09.2017.

Franz Josef I. 1857. *Wiener Telegraf* 297 (1857, December 29). Wien.

Stadt Wien. 2012. Weltkulturerbe Wien. Retrieved from: https://www.data.gv.at/katalog/dataset/12426052-8803-4deb-8c89-9e78785f7dd2 on 14.09.2017.

Stadt Wien. 2017. Gebäudeinformation Standorte Wien. Retrieved from: https://www.data.gv.at/katalog/dataset/7a8aae59-71a4-4500-b38b-bdf15c7f627f on 14.09.2017.

Historic Wales. 2019. "Historic Wales". Retrieved from: https://historicwales.gov.uk/#zoom=0&lat=300000&lon=258000&layers=BFFFFFTFFTTT on June 19, 2019.

Land Tirol. 2019. "Kulturkataster Tirol". Retrieved from: https://maps.tirol.gv.at/tirisMaps/synserver?project=tmap_master&user=guest&view=sport_kunst on June 19, 2019.

Manfred Wehdorn, Günther Buchinger, Ludwig Varga, and Marion Schwarz, eds. 2011. *Baualtersplan Wien: innere Stadt*. Wien: Freytag & Berndt.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz
The editor's office is not responsible for the linguistic correctness of the manuscripts.
Authors are responsible for the contents and copyrights of the illustrations/photographs.

Evolving from Castle to Virtual Space: The Case of Kyrenia Shipwreck Museum

ZEYNEP CEYLANLI, EZGİ ÇİÇEK, and PELİN ARSLAN, Özyeğin University, Istanbul, Turkey
PEMBE ÖZEN, Department of Antiquities and Museums, Nicosia

The past twenty years have seen a progressive innovation in the approach to the museum pedagogy, an increasing use of digital solution has more and more influenced the way the items, the history and the knowledge are transmitted. The architectural design aspect of such interventions is influenced by these new approaches increasing the need of knowledge about technology solutions owned by architects and cultural heritage experts. These rules are applied in many cases of new museum constructions, but often they must also be applied in existing museum exhibitions. In the case presented here, the Museum sector of the Kyrenia castle, located in the northern part of Cyprus, place of the exhibition of one of the first underwater archaeological finding, will be taken with all its specific issues and will be analyzed and presented as an exploring experience of new multimedia/traditional solutions, cataloguing some interesting and well promising solutions for media integration and online/site specific integration, together with contemporary materials/exhibition solutions in the aim of a renewal proposal capable of bringing in the digital age and enhancing the quality of the visiting experience of this interesting museum/castle. The case under scrutiny gives us the opportunity to reveal the layers of different phases of the castle as well as an antique shipwreck with the use of 3D digital survey of the architectural space, which concomitantly leads the way for the museum design solutions to cooperate with the digital technologies.

Key words:
Museum Design, Site Specific Museum, Digital Museum, Kyrenia Castle, Museum Pedagogy.

CHNT Reference:
Zeynep Ceylanlı et al. 2018. Evolving from Castle to Virtual Space: The Case of Kyrenia Shipwreck Museum.

INTRODUCTION

This paper aims to shed light upon the contemporary museum design tendencies in historical sites and digital technologies used within while focusing on the design proposal of a shipwreck museum. Museology and museum design had been a hot debate since the late twentieth century. The changes in the ways of perception and progressing information technologies paved the way for the contemporary museum design to be more involved in digital platforms using “information and communication technologies” (ICT), where the main aim is to provide a better connection between the visitor and the collection of the museum. Not only affecting the tangible-material existence of the museum, digital platforms also alter the whole idea of the museum itself; the meaning of the museum along with its pedagogical purposes is under revision. On the other hand, when the museum is already in a given historical context, such as when it is built in historical heritage site, it becomes an obligation to provide the visitors to observe the existing building as a part of the collection. The case study in this paper is an example to this kind of museums; Kyrenia Castle Museum is located inside the medieval castle that has been used and went through different phases by different occupiers [Camiz et al. 2016; 2017].

Authors addresses: Zeynep Ceylanlı, Department of Interior Architecture & Environmental Design, Özyeğin University, Nisantepe Mah. Orman Sok. No:34-36, 34794, Çekmeköy / Istanbul, Turkey; email: zeynep.ceylanli@ozyegin.edu.tr; Pembe Özen, Haydarpasa Street, Old BTMK Buildings, Selimiye Mosque, Nicosia; email: pembe.ozen@gmail.com; Ezgi Çiçek, Department of Interior Architecture & Environmental Design, Özyeğin University, Nisantepe Mah. Orman Sok. No:34-36, 34794, Çekmeköy / Istanbul, Turkey; email: ezgi.cicek@ozyegin.edu.tr; Pelin Arslan, Department of Architecture, Özyeğin University, Nisantepe Mah. Orman Sok. No:34-36, 34794, Çekmeköy / Istanbul, Turkey; email: pelin.arslan@ozyegin.edu.tr

Not only the exhibition techniques of the collection matters in the design process, but the media used to work on and to represent the design idea also affects the process as well as the end-product. Through the international one-week-workshop held in May 2018 on the site, a thorough study was conducted by several study groups on understanding the current condition of the castle and proposing ways of documenting, restoring, and redesigning. The fundamental outcome of the workshop was the collaboration of the groups examining the castle with different means of expertise and interweaving the whole study groups to finalize the documenting, restoring, and redesigning of the castle. One of the common issues shared by the groups was the use of new technologies; the design groups as well included the current technological advances in their proposals, while obtaining their preliminary design materials regarding the existing condition of the castle from the lasergrammetry team, converting the cloud-base information into CAD format. After giving a brief overview on the existing literature about the contemporary museum studies and overall information about the formation of the workshop, one of the design proposals will be discussed in this paper, revealing the design approach, the materials and technological means used in the museum.

AN OVERVIEW

Debates on the formation of museums and their role in the society has been continuing for the past decades [Paddon 2014; McCall and Gray 2013; Hooper-Greenhill 2007; 2004]. Recently, with the rapid advances in ICT, the museums became a suitable venue to apply new versions of presenting the collection and thus communicating with the audience. Yet in addition, it is even more favored to use new technologies in the cultural and historical heritage sites to promote and make the information more accessible [Empler 2018; Li and Liew 2015]. The new means of digital interaction technologies such as smart screens, “Virtual Reality” (VR) and “Augmented Reality” (AR) enhance the museum experience and improve the personalized experience of the museum space and the collection. The relation between the content of the exhibition and the context where it is constructed into is also a matter of issue, since the museums bear a certain meaning in their own existence. The architectural and exhibition design of the museum, thus, play and important role in this meaning, simultaneously affecting the communication between the collection, the (hi)story and the visitor. With reference to Papastergiadis’ perception of spatial practices on art and politics, McCulloch and Williams-Wynn state that

> *“meaning is generated, in part, through the relationship between the physical layout of the exhibition space and the historical, political and social associations of the exhibition site.”*
>
> [McCulloch and Williams-Wynn 2015, 284]

A worldwide acclaimed organization, ICOMOS (International Council on Monuments and Sites), was established to focus on the topics such as future of cultural landscapes, sites of memory, strengthening capacities of world heritage sites in different landscapes, cultures, sites and monuments. Regarding the fact that the museum in concern of this paper is located in a historical heritage site, it was equally important to look at the museum examples worldwide which are already built in existing cultural and historical heritage sites:

- Castelvecchio Museum in Verona, northern Italy, is also located in a medieval castle. Intervention by the architect Carlo Scarpa between 1959 and 1973 has enhanced the appearance of the building and the exhibited artefacts. Scarpa's language is visible in the details for doorways, staircases, furnishings, and even fixtures designed to hold a specific piece of artwork or emphasize the spatial details of the castle [Goffi 2016].
- Kolumba Museum is situated in Cologne, Germany, a city that was almost completely destroyed in World War II; the museum houses the Roman Catholic Archdiocese’s collection of art which spans more than a thousand years. Peter Zumthor’s design derives from the ruins of a Late-Gothic church by understanding and revealing the site’s history, reflecting the meaning of the site on the architectural space [Norton et al. 2008].
- Museum of Science and Industry in Manchester, England, was designed by Walker Simpson Architects and it reserves a significant place in the city’s history since the building is the world's first inter-city railway station. The architects’ approach to the whole complex is formed around creating frames to view the scenes from the heritage site, including the power hall and the warehouse [Harvey 2004].

THE WORKSHOP

Reading and Designing the Kyrenia Castle International Design and Seminar-Workshop that hosted by Girne American University in Kyrenia in the island of Cyprus, took place between 6 and 13 May 2018 with the participation of tutors and students from Özyegin University, University of Florence, Rome La Sapienza University, and Karadeniz Technical University. The main purpose of the workshop is to analyze Kyrenia Castle which has an ancient history and to come up with a design proposal for the shipwreck currently exhibiting inside of the castle in order to enhance heritage in the historical landscape. The workshop was formed by the distribution of participating teams around the main topics as design and survey at the beginning of the process. Design teams' processes are intended to be based on the data obtained from the survey team, thus increasing the applicability of the design interventions.

Tutors and students of the design team were divided into three different groups to work on their own proposals during the workshop. In addition to their groupings, the survey team has been consisted of several sub-teams of those who will work with drone, to learn photogrammetry and lasergrammetry techniques from tutors and to apply into the castle, those who will contribute to the analysis of documentation of the castle walls and the material analysis, and 3d laser digital survey techniques with the special equipment.

Following the identification of the groups, the series of seminars, which consisted of the methods and techniques to be used later, displayed successively. These seminars were supported by presentations of various researchers and professionals in from different countries, universities and industries using similar methods and documentation.

Cooperation and time schedule in this sense posed a significant role to achieve this kind of collaborative work. Some data needed to be completed, such as cross-sectional, visual, and aerial photography, by the survey team initially and to be transferred the work done for better processing of the design team with them. Although this seems to be a difficulty at first glance, the team members were able to complete the job within the defined time, and this could be overcome by smart planning at the beginning of the workshop.

THE MUSEUM DESIGN

Current state

The museum is currently located on the northeastern side of the castle and consists of five cells where the previously demolished sixth cell's plan is still visible for the visitor's eyes. The fifth cell is currently hosting one of the oldest trades shipwreck of the world; the Kyrenia Shipwreck. According to the museum's present organization, the visitors are starting their tour from the first and second cell which are interconnected and hosting Vrysi settlement and artefacts exhibition. Later they have to exit out and again enter the third cell for the excavation exhibition and fourth (interconnected to third) for shipwreck findings. Finally, after seeing the findings such as amphoras, curse tablet, grain mills; visitors climb up to the fifth cell for seeing the shipwreck (only entrance for the visitors).

Problems defined

According to the main observations made by the design team, after thoroughly investigating the current state of the museum and the visitor behaviors; this circulation flow was detaching visitors from the exhibitions because there was no clear path to follow. The visitors were roving around (disorienting, interrupted and not regulated movements; exiting and re-entering, going up and down) without proper narrative flow for catching and holding their attention; without knowing which content they will see next in the following cell. Finally, when they reach the shipwreck cell, through a narrow prosaic and imperceptible staircase, a catwalk makes the visitors walk around to investigate the shipwreck from above. Museum officials explained that the biggest problem of the museum is actually the current state of this cell, where the design proposal accentuates the significance of this cell by extruding the casing towards the main courtyard of the castle.

The current open exhibition of the fragile ship makes it vulnerable for the dust that old castle ceiling create, human factors and all the possible natural occurrences. Another issue was the lack of space for exhibiting shipwreck findings. Later, the museum officials mentioned that there are many more amphoras sitting in the ill-conditioned storage waiting to be exhibited. Moreover, even the artefacts on exhibitions are not preserved properly like the shipwreck. The third concern was the visitor's experience; exhibition techniques are dated and not efficient enough

to tell the story of the exhibitions. As mentioned before, the visitors seem to leave the Kyrenia shipwreck castle without having the information that the museum tried to provide.

Design proposal

The design team, consisted of two architecture students and two tutors, firstly focused on easing the circulation flow in order to excel in the narrative. (Fig. 1) Every two cell is connected to each other from the first floor but also all cells are connected with window-passages to each other. Therefore, all the existing openings in the museum are used in order to provide uninterrupted circulation (keeping the visitors always inside the museum). The second entrance is also used to provide a direct passage to the temporary exhibition that the museum administration demanded. Moreover, elevated glass floor is designed by the team for creating additional exhibition surface to display the original artefacts in a more controlled area. In the fifth cell, the projected video of the reconstructed ship helps the visitors to imagine the ship sailing in the Mediterranean Sea and for more hands on experience the smart screens with remote touchpads provided in order to give more elaborate information and stories of the shipwreck (Figs. 2 and 3) Although the preliminary aim was to introduce VR headsets and a smartphone application to provide virtual experience through AR and QR code, the time limitation of the workshop withheld the design team to propose such interventions. Meanwhile, the sixth cell is erected again to serve the needs of providing better storage for amphoras which will be also used as a surface for exhibiting them. Moreover, a museum shop is suggested here, which will be one of the major sources of income to keep a museum running. Also, wet areas are located in this part with using already existing toilets infrastructure systems.

The sixth cell's material choice is perforated sheet covering, in order to catch visitors' attention from the outside of the museum. (Fig. 4) This material is used because of its affordable, weather resistant, sustainable characteristics, therewithal its humble features such as color choice and its pattern, blend in with the porous stone walls of the castle without getting ahead of the castle itself. In order to give more space for shipwreck exhibition, the wooden partition is removed and an extension is suggested for circulation. The perforated sheet is again used for this pop out extension, letting the intervention made by the design team to be read from the outside. With this extension, the visitors are starting their shipwreck experience from the beginning of the catwalk in the upper floor at the fourth and fifth cells' connection door and going down at the Z plane (pop out extension), finishing their journey at the zero level; entering to the museum shop with another portion of amphoras exhibited (the sixth cell).

REMARKS

This study looked at the current debates on the museum design in a heritage site and worked on the design proposal of the shipwreck museum inside the Kyrenia castle. (Fig. 5) Designing a museum in a heritage site, regarding the existing structure, the collection with varying scales, and the creation of a narrative for the visitors, is a challenge for the architects and exhibition designers. However, documenting, restoring, redesigning, and storytelling of the museum improves with the usage of digital technologies, also it heightens the communication between the visitor and the exhibited artefacts while bettering the architectural space as an end product.

The design intervention was a key element of the whole process due to the fact that its entire teams were dedicated to making workshop reach a conclusion on the way through the reasonable and respectful design proposal in the special historic environment and trying to process the data in the best way. Particularly the significant point in this workshop was data sharing among teams, hence between 'design' and 'digital survey'. Otherwise, it would reduce the efficiency by prolonging the process if the labor sharing would not happen during the workshop among teams. Another noteworthy point was the quality of the surveys and the use of digitally based techniques. This also facilitates the accuracy, transferability and storage of data while providing benefit in terms of both time and labor.

For prospective researches, this study is regarded as a basic exemplary model in approaching the design process by all the aspects of the design tools, on-site data, conceptual configuration, and digital representation.

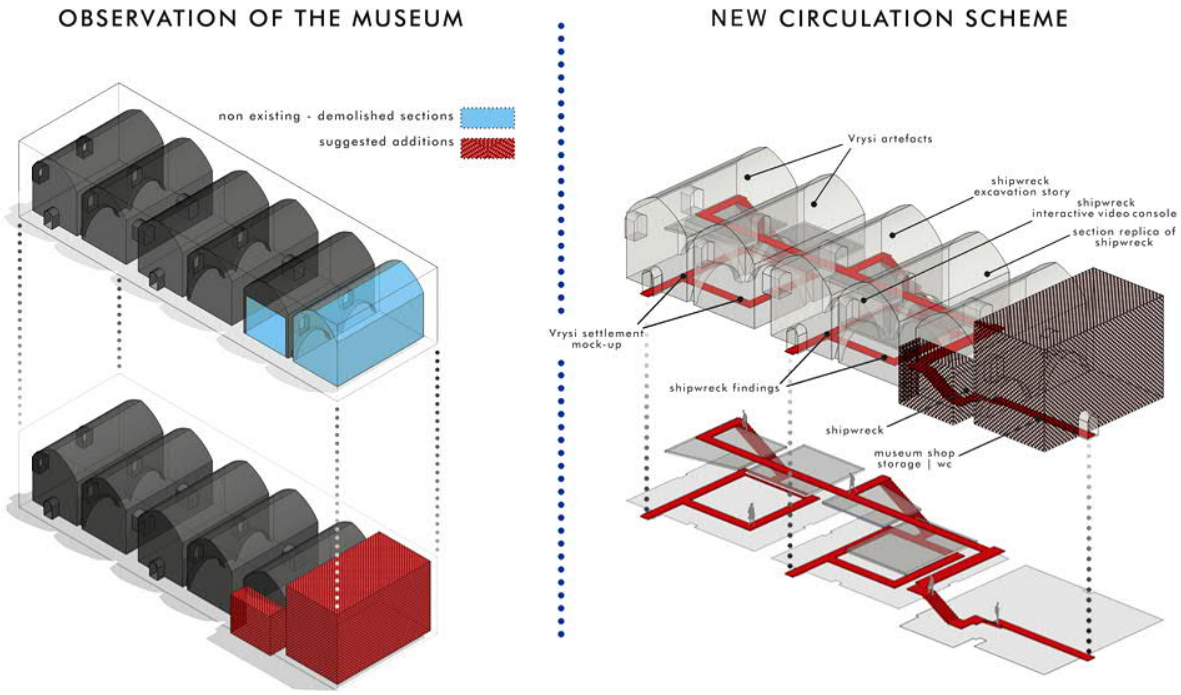


Fig. 1. Observation of the current state of the museum and the new circulation proposal

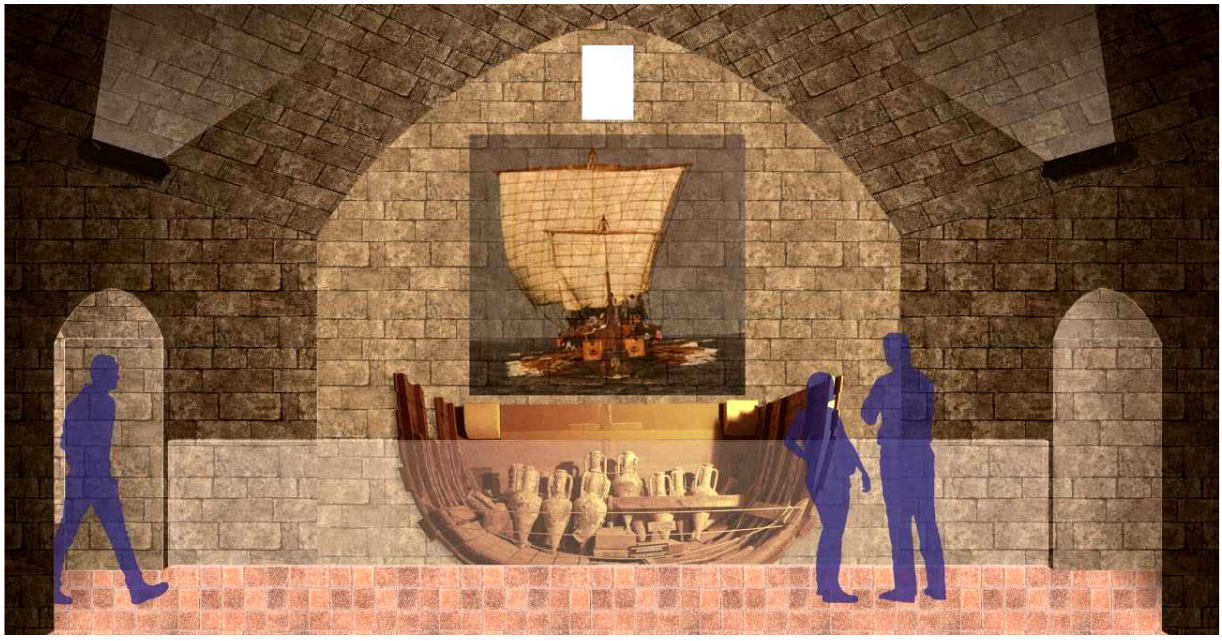


Fig. 2. Mock-up ship section and genuine amphoras, with a 3-minute-video projected above

Fig. 3. Smart screen with remote touchpads presenting the interactive storyline

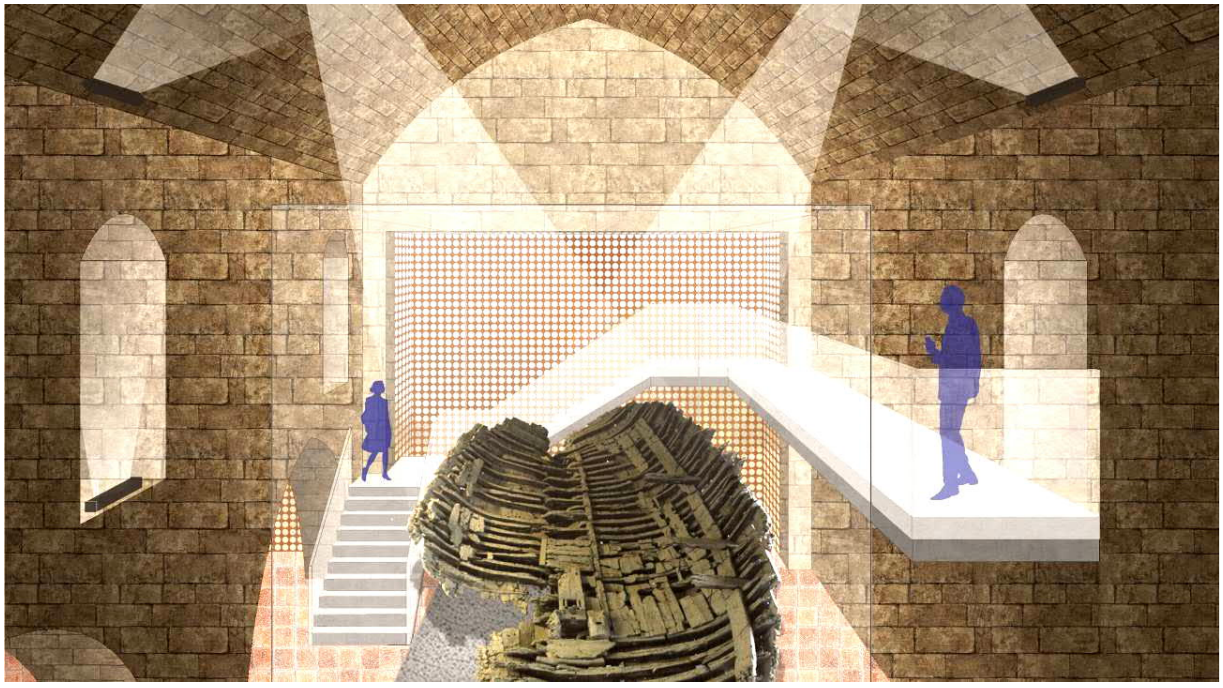


Fig. 4. Kyrenia shipwreck in its glass casing – perforated metal sheet extrusion is seen behind

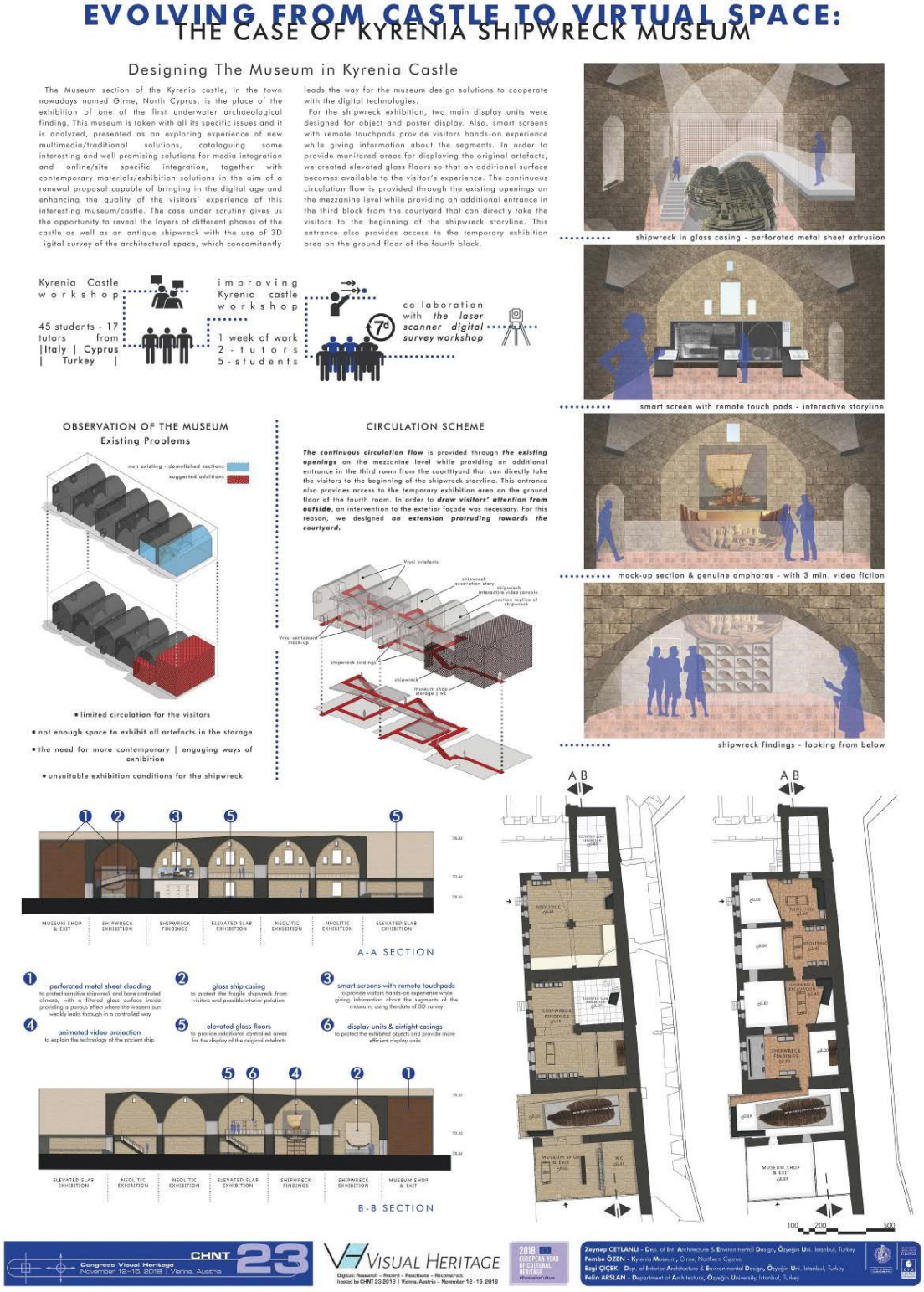


Fig. 5. The poster (original in UNI A0 format) as presented in occasion of the Cultural Heritage and New Technology / Visual Heritage Conference, Vienna, 2018

ACKNOWLEDGEMENTS

The workshop “Reading and Designing the Kyrenia Castle” is one the results of the ongoing scientific collaboration between Girne American University (Department of Interior Architecture), with the Department of Architecture of the University of Florence and the Department of Interior Architecture and Environmental Design of Özyeğin University. The workshop took place between the 6th and the 13th of May 2018, with the hosting of Girne American University. The design team of this paper is consisted of Assist. Prof. Dr. Zeynep Ceylanlı, Res. Asst. Ezgi Çiçek, MSc, architecture students Ege Poyraz and Furkan Öztopbaş (Özyeğin University).

REFERENCES

Alessandro Camiz, M. Griffo, S. Baydur, F.T. Fidan, and S.I. Khalil. 2017. The round corner tower of Kyrenia's city walls (1211-1232). In A.B. González Avilés, ed. *FORTMED 2017. Defensive Architecture of the Mediterranean. XV to XVIII Centuries*. vol.4. Alacant: Publicacions Universitat d'Alacant, 55-62.

Alessandro Camiz, S.I. Khalil, S.C. Demir, and H. Nafa. 2016. The Venetian defense of the Mediterranean: The Kyrenia Castle, Cyprus (1540-1544). In Giorgio Verdiani ed. *FORTMED 2016. Defensive architecture of the Mediterranean. XV to XVIII Centuries.* vol. 3. Firenze: DIDApress, 371-378.

Thomaso Empler. 2018. ICT to Communicate, Represent and Enhance an Archaeological Area. In Giuseppe Amoruso ed. *Putting Tradition into Practice: Heritage, Place and Design Proceedings of 5th INTBAU International Annual Event.* Springer, 692-702. DOI: 10.1007/978-3-319-57937-5

Federica Goffi. 2016. Built Conservation and the Unfinished Fabrics of Time. *Architectural Design*, 86, 1 (Jan/Feb2016), 24-33. DOI 10.1002/ad.1998

Penelope Harvey. 2004. Memorialising the Future: The Museum of Science and Industry in Manchester. In Mary Bouquet and Nuno Porto eds. *Science, Magic and Religion: The Ritual Processes of Museum Magic*. Berghahn Books, 29-50.

Eilean Hooper-Greenhill. 2007. *Museums and Education: Purpose, Pedagogy, Performance*. Abingdon: Routledge.

Eilean Hooper-Greenhill. 2004. *Museums and the Shaping of Knowledge*. London and New York: Routledge.

Vikki McCall and Clive Gray. 2013. Museums and the ‘new museology’: theory, practice and organisational change. *Museum Management and Curatorship*. 29,1 (2013), 1–17. DOI: 10.1080/09647775.2013.869852

Samantha McCulloch and Christopher Williams-Wynn. 2015. Conflicts between context and content in *William Kentridge: Five Themes*: a case study of the Melbourne exhibition. *Museum Management and Curatorship*. 30, 4 (2015), 283-295. DOI: 10.1080/09647775.2015.1060866

Teresa Norton, Lesa Mason, and David C. Overholt. 2008. At St. Kolumba: The Drowned and the Saved - Transmitting the Spirit of Place-Interpretation / Meaning. In *16th ICOMOS General Assembly and International Symposium: ‘Finding the spirit of place – between the tangible and the intangible’*, 29 sept – 4 oct 2008, Quebec, Canada. Retrieved from https://www.icomos.org/quebec2008/cd/toindex/77_pdf/77-nyV1-142.pdf

Hannah Paddon. 2014. *Redisplaying museum collections: contemporary display and interpretation in British Museums.* Surrey: Ashgate.

Richard Yu-Chang Li and Alan Wee-Chung Liew. 2015. An interactive user interface prototype design for enhancing on-site museum and art gallery experience through digital technology. *Museum Management and Curatorship*. 30, 3 (2015), 208-229. DOI: 10.1080/09647775.2015.1042509

The recent digitally reconstructed model of Kyrenia Shipwreck can be viewed and interactively navigated in the following link: https://sketchfab.com/3d-models/the-kyrenia-shipwreck-d573f1c02483453bab78d166c49070eb (survey and 3D modeling by Giorgio Verdiani and Francesco Capparelli from the workshop’s survey team)

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz

Old and New School, the Evolution of the Survey Campaign in a Case Study about the Maddalena's Bridge

AMBRA COLACIONE, PAOLO FORMAGLINI, and FILIPPO GIANSANTI, Dipartimento di Architettura, University of Florence, Italy

Abstract: How can we make the heritage built around us available through the new digital survey technologies?

The Maddalena's bridge, in Borgo a Mozzano (LU) Italy, called "Devil's Bridge", is a monument of particular historical interest and it has been analyzed here with the aim to identify new way about how to use the data of a survey campaign through using different technological methodologies (3D laser scanner and photogrammetry) and new "Structure from Motion/Image Matching" (SfM/IM) software. The use of both data allows a greater amount of detail and better management of the survey campaign timing.

Some buildings, such as a bridge, located in specific topographical conditions may present some difficulties with survey's technologies. In this case, the water affected the normal return of the data through the laser scan; also, the photogrammetric survey sessions obviously present physical barriers such as in our case the river, not navigable at the time of the survey campaign.

Therefore, the combined use of both 3D laser scanner and the photogrammetric survey was indispensable to provide better detail accuracy. The new survey made in 2018 and its graphic restitution of Maddalena's Bridge, wants to be a usable basis to benefit from a comparison with a previous survey carried out in 2006, allowing us to analyze and compare the status of the current fact with the previous one and thus allowing hypothesizing possible consolidation and redevelopment interventions if necessary. Thus, it was possible to highlight the changes offered by the new technological solutions that we now have available (the evolution of the 3D Laser-scanner, optical devices and cameras, software and digital components) and that allow us to implement the knowledge of the survey.

Thanks to the survey itself, it was possible to create a 3D digital model available for complete use of the monument for tourism purposes.

Key Words:
Photogrammetry, Structure from Motion, Maddalena's Bridge, Data comparison

CHNT Reference:
Ambra Colacione et al. 2018. Old and New School, the Evolution of the Survey Campaign in a Case Study of Maddalena's Bridge.

INTRODUCTION

The Case Study

The object of our investigation is the Maddalena's Bridge, also called Devil's bridge because of the legend about its construction, that is located in Tuscany (Italy) and joins the two banks of the river Serchio near the village of Borgo a Mozzano, a small medieval village in the province of Lucca and is located just after the confluence with the Lima torrent. The geographical context in which the Maddalena's bridge is located is the Serchio river basin, which characterizes the morphology of the whole area. The complex orographic system has characterized not only the infrastructural evolution of the territory, but it is also the origin of the singular "back of donkey" shape of this bridge. [Repetti 1843]

Authors addresses: Ambra Colacione, Dipartimento di Architettura, DIDA università degli studi di Firenze, Italia. email: ambra.colacione@hotmail.it; Paolo Formaglini, Filippo GIansanti, Alessandro Giacomelli Dipartimento di Architettura, DIDA università degli studi di Firenze, Italia. Email: lfa.dida.unifi@gmail.com

HISTORICAL OVERVIEW

The lack of sources related to the Maddalena's Bridge hardly allows us to distinguish the myth from reality, history from legend. We can therefore advance hypotheses by collecting testimonies, representations, stories and traditions around this artifact trying to reconstruct the events around its construction and its use, from being an infrastructure work of great importance used largely for travel, until its final change of role.

For this reason, it is important to understand the evolution of the infrastructural and road system of the neighboring territory so that we not only understand the importance that the Maddalena's Bridge has taken over the centuries as a way of communication, but how it has come until today, even if with big changes and if its primary function had ceased.[1]

We will then make a brief chronological outline of the historical events that have characterized the monument:

Roman Age

The importance of speed in military travel has allowed the construction of direct and efficient routes. The Tavola Peutingeriana[2] describes a probable existence of a crossing on the Serchio river at Borgo a Mozzano. [Duè 1994]

Medieval Age, 6th century, Lombard conquest

The road network is in crisis with the decline of the Roman Empire. The paths chosen by the first Langobards developed along the ridges, thus avoiding the crossing of rivers and tracing much of the paths used for transhumance.

The Via Francigena and the Pilgrimage

With the arrival of the Franks, the network of Langobard streets is strengthened and becomes part of the most important arterial road between Europe and Rome, the Via Francigena.

Lucca is a fundamental stop for pilgrimages, which soon becomes a cosmopolitan dimension and enriches with churches, hospitals and shelters.

Matilda's Age, Canossa's domination 1002-1115

Matilde of Canossa controls much of the kingdom of Italy, from the area north of the Apennines to current Tuscany. Tradition describes the construction of the Maddalena's Bridge, by the will of the countess.

Republic of Lucca, and Castruccio Castracani

In these years Castruccio Castracani, lord of Lucca from 1316 gathered under his kingdom a large number of territories. Some sources attributed to Castruccio a probable reconstructions of the Maddelena's bridge following a collapse. The politics of the Lucchese state, not being able to rely on an efficient army, is oriented to make access to the territories of the state difficult, and maintenance is progressively neglected.

16th and 17th centuries, the Charter of Lucca

In the "Charter of the state of Lucca" of 1569 the main connection between Lucca and Garfagnana still follows the medieval route. Only in the 1600s the Lucchese government decided to build a new road on the left bank to replace the ancient route, but this one too was not very easy. The transport with ~~the~~ vehicles becomes widespread and instead of crossing of the Maddalena's Bridge (already complex for coaches and carriages) crossing the river on special boats is preferred. Now the bridge becomes an infrastructure almost exclusively for the inhabitants of Borgo a Mozzano.

New unitary state and new infrastructures: The railway

At the end of the 19th century the new government supported the development of the railways, with both a military and commercial purpose. The Maddalena's bridge is located along the second stretch of the Lucca-Aulla railway.

[1] I luoghi del silenzio. http://www.iluoghidelsilenzio.it/ponte-della-maddalena-detto-anche-del-diavolo-borgo-a-mozzano-lu/
[2] Tutta Toscana. https://tuttatoscana.net/curiosita-2/la-toscana-rappresentata-nella-tavola-peutingeriana/

The construction of the railway has modified the physiognomy of the bridge, making the bridge even more uncomfortable for the increased slope.

From infrastructure to monument:

The Maddalena's Bridge ceases almost exclusively of its usefulness, thanks also to the construction of the Umberto I's bridge (1902), except after September 1944, where it remains the only passage after the destruction of all the other bridges over the Serchio that were practicable for the German vehicles, more cumbersome than the American ones. It was this "inefficiency" that kept its charm intact to this day. [Gucci et al. 2010]

THE MYTH

The Maddalena's Bridge is not the only bridge in Italy (and in Europe) to have been renamed "Devil's bridge". In the Middle Ages, in fact, the construction of a bridge was considered almost prodigious and magical, partly due to the loss of familiarity with the construction practices of the Romans, the lack of new buildings and the abandonment of existing ones. This is why the construction of new architectural works of ancient engineering have given rise to many legends, often starring the Devil himself, because joining two places that nature (and God) had wanted separated was seen by many as a "diabolic" gesture that only the devil could complete.[3]

In fact, many "difficult" works, in popular tradition, were built by the devil: from the Cologne Cathedral to the Abbey of Mont Saint Michel in France and even to the Verona Arena. To these great enterprises must be added numerous palaces, castles, mills, and fountains. But what was attributed as a devil's bridge? The devil's bridge is a stone, brick, wood (today we add reinforced concrete), and iron "donkey's back shape" placed in a "steep gorge to overcome impetuous waters". There are also "devil's bridges" of natural origin, carved into the rock or ice by water or other atmospheric agents. Therefore, there is no ideal model of "Devil's bridge": it is the legend that, to "certify" the final work, assigns the construction to the Devil, since man would not be able, with his strength, to realize such an impressive undertaking. [Lera, 2014; Cenami 2002][4]

THE SURVEY CAMPAIGN

The surveys and subsequent digital evaluations were conducted between December 2016 and July 2018 together with a group of Architects of the Department of Architecture of the University of Florence coordinated by Prof. Giorgio Verdiani. The aim was to carry out a detailed digital and photographic survey aimed at creating the correct foundations for the following studies and analyzes.

In the first analysis we conducted a survey campaign with a 3D laser scanner. (Fig.1).

The principle on which a 3D laser scanner is based upon is to acquire the spatial coordinates of an object automatically, systematically, and quickly thanks to the projection of a laser light beam on the object and the analysis of the return signal. The laser scanner unit emits a laser signal in one direction and on the basis of the variation of the phase present in the reflected light towards the unit the distance of the reached point is identified, this measure, combined with the measurement of the horizontal and vertical angles, according to which the signal has been emitted, it allows to position with good precision the point reached, thus going to create, for reiteration of the operation, a three-dimensional digital model. The overall model of a series of measurements performed through the laser signal thus constitutes a three-dimensional digital model that today is generally referred to as a "point cloud". For each single point the RGB values of the "reflectance" are stored (its value depends on numerous factors, among which the characteristics of the materials, their processing, the angle of incidence of the laser signal, the atmospheric conditions and the distance of the measured object) and therefore the color of the laser reflected signal which has a chromatically altered, but well-differentiated version of the real object. Among the most important features of this survey methodology are the accuracy of the acquisitions (the accuracy with which it is detected can have a precision of four millimeters) and the speed of data acquisition. The survey establishes a precise measured image that becomes the basis of the knowledge of the shape of the monument over time.

[3] Wikipedia: https://it.wikipedia.org/wiki/Ponte_della_Maddalena
[4] Castelli Toscani: http://www.castellitoscani.com/italian/diavolo.htm,
La tela Nera: http://www.latelanera.com/misteriefolclore/misteriefolclore.asp?id=121

Fig. 1. One of the 44 laser scanner stations in Maddalena's Bridge

It will always be possible, by carrying out a new survey at another time, to check for any changes in the monument, to understand the reasons and to carry out significant safeguard operations.

The point cloud is transparent, discontinuous and composed of dimensioned elements, chromatically altered and is not easily transferable outside specific data management software. The problem arises, therefore, of making transformations on the cloud of points that allow the model to be returned in a comprehensible manner, keeping the aims very clear.

Currently the hardware and software tools in use can lead to transformations that see from an extreme the maximum correspondence to the model and the other to the perceived real. First it is necessary to have a transition from the discontinuous model to a single continuous model, in such a way as to bring it back into a context of more usual graphic rendering for the designer and for the multimedia designer. In this way the elements acquire their real opacity, complicating the model to the point of requiring hardware resources that are very expensive to visualize. For this reason, it is necessary to resort to simplification operations of surfaces, more or less massive, which lead to a reasonable level of management of the model in progress such as the use of generic textures or specific textures derived from photographs of the real model. For multimedia productions with development of animated or interactive sequences it is necessary to use a simplified object to such an extent as to arrive at rough approximations in favor of a better perceptual performance. [Recati 2017]

The scanner used was Zoller+Fröhlich Imager 5006h. The 3D survey with the laser scanner was carried out in a single day, positioning the instrument in different points suitable to cover the whole of Maddalena's Bridge, called stations. In this case, 44 stations were necessary to have complete coverage of the monument.

The instrument must be able to "see" at least two targets that reconnect it to the support network or another station, while the third reference is given by the verticality of the instrument, certified by the previous leveling.

The greater the number of targets beaten for each scan, the more precise the collimation will be achieved when recording the point cloud, subsequently processed through the use of the *Autodesk ReCap PRO*[5] software.

[5] https://www.autodesk.com/products/recap/overview

PROBLEMS WITH WATER

One of the problems that were found through the 3D survey performed with the laser scanner was the presence of the water under the bridge. Water has created disturbances in transmission and rebound of light. The laser has processed erroneous points that have come to rebound and have been identified as material. The original model thus becomes "dirty". In fact, the surface of the cloud of points in areas near the water's reflection is not exactly clean, does not follow a single surface.

PHOTOGRAMMETRIC SURVEY

To integrate the data provided by the relief described above, it was necessary to create a photographic covering of the article in parallel. Photogrammetry is a technique that allows the acquisition of form and position of an object through the analysis of two stereometric frames. Used in cartography since the second half of the 18th century, it has had an important impetus in recent years with the development of digital photography and computers capable of handling relatively large amounts of data. It is, therefore, a method of economic importance, non-invasive and that provides rapid and highly effective results.

The photogrammetric survey consists of a precise sequence of operations performed with adequate instrumentation:

- Nikon DSLR D800E, a camera with high image quality (the higher the pixel resolution of the camera sensor, the better the image will be captured), at 36.3 Megapixels and mounting high quality lenses (a 24-120 mm F4 Nikkor Zoom and a 150-500 mm F6.3 Sigma Zoom Lens)

- A tripod with adequate stability and adequate characteristics

- High performance personal computers and amount of RAM memory

- Software for photogrammetry

- Software for the management of surface models and for the production of rendered images

For the photogrammetric survey of the Maddalena’s Bridge, a Nikon D800E was used, with a 36.3-Megapixel FX sensor, with a Sigma 150-500 mm focal length telephoto lens for long-distance shooting by the ENEL dam facing one side of the bridge. Other shots were necessary with different focal lengths and framing angles for better and greater precision in the subsequent restitution of the photogrammetric datum, made with an 18-105 mm and a 70-200 mm both with the aid of a tripod and by hand free.

Constant photographic exposure problems:

Managing the camera totally in manual, the main trick that has been taken into account was to try to maintain an always constant exposure in all the shots, although the lighting conditions of the object varied, due to the different position of the sun during the shooting phase (which is why the shots were taken in the shortest possible time) both in the shaded areas or in the light of the bridge itself. To maintain the best possible homogeneity, the exposure management parameters (ISO, diaphragms, exposure time) have been changed, keeping the diaphragm constant, to try to keep it always with a setting that is as closed as possible to obtain a better depth of field, both the ISO, as low as possible, to 200, to avoid the creation of digital noise that would disturb the quality of the shot. So, with the aid of a tripod to avoid blurred or micro wavy shots, we have lengthened the shutter speed when it was necessary for exposure in the darkest areas or in the shade. (Fig. 2).

POINT CLOUD MANAGEMENT WITH AUTODESK *RECAP PRO*

As a first processing of the survey data, it was necessary to import the scans made by the laser scanner on the Autodesk *Recap PRO* software to make a preliminary "registration" of the starting data. After importing the laser scanned files into the RCS format, the software is able to "record" them, that is, to compose them according to the shooting scheme to form the complete three-dimensional model. The software reads the individual scans and compares them to find collimations with the others. To perform this function, it uses an internal self-registration function, to which a manual registration part is added in case some scans are not recognized and remain vacant. This procedure has allowed us to obtain a cloud of points rather light considering the least amount of data within it and accurate in terms of average error. We are talking about very small errors, in the order of +/- 0.6 mm. (Figs. 3-4). [Piangiani 2018]

Fig. 2. Photographic acquisition phase: example of a sequence of shots taken under conditions of constant exposure. Photographs taken with a telephoto zoom lens at a focal length of 500mm from the ENEL sluice overlooking the bridge. For a better photogrammetric reconstruction, due to the perspective distortion given by the telephoto lens, it was necessary to include shots made with less extended focal lengths to allow the correct restitution of the depth of field.

MERGING THE DATA: A SAFER AND OPTIMIZED ANALYSIS

In conclusion to these two relevant campaigns, we find ourselves having two data in our possession: the photogrammetric data and the data acquired with laser scan. The procedure for the correct analysis of the survey is to compare the two data in order to have greater precision, and it is important to be able to compare the two findings if any problems were encountered.

When, however, after a comparison between the two surveys, discordances are observed, even if minimal, it becomes complicated and laborious to understand which of the two is incorrect and which one is with the least possible margin of error.

For this reason, it was used a software like *Reality Capture* that allows the processing of both data simultaneously, just to go to eliminate this type of error. Through the use of photographic texture mapping we can project photographic images directly on the 3D metric model obtained in output from the scanner. This methodology involves the combined use of photogrammetry and laser scanning. The scan provides the metric data and the “digital

model of the object" (DSM); the photograph is then projected onto the model. To make this procedure possible, the external orientation parameters of the DSM must be known. In this way the scan obtains the radiometric information from the different photos, obtaining, in output, a DSM with applied photographic textures. The effect obtained is remarkably realistic and pleasant; moreover, it allows to more accurately investigate the state of conservation of the object. From this product, by performing an orthogonal projection on any plane, it is possible to obtain the precise orthophoto.

We have therefore optimized the times and at the same time a much greater precision, because the integration between the two data allows a better return, with the aim of giving new life to our cultural heritage, of which the devil's bridge is the first in question.

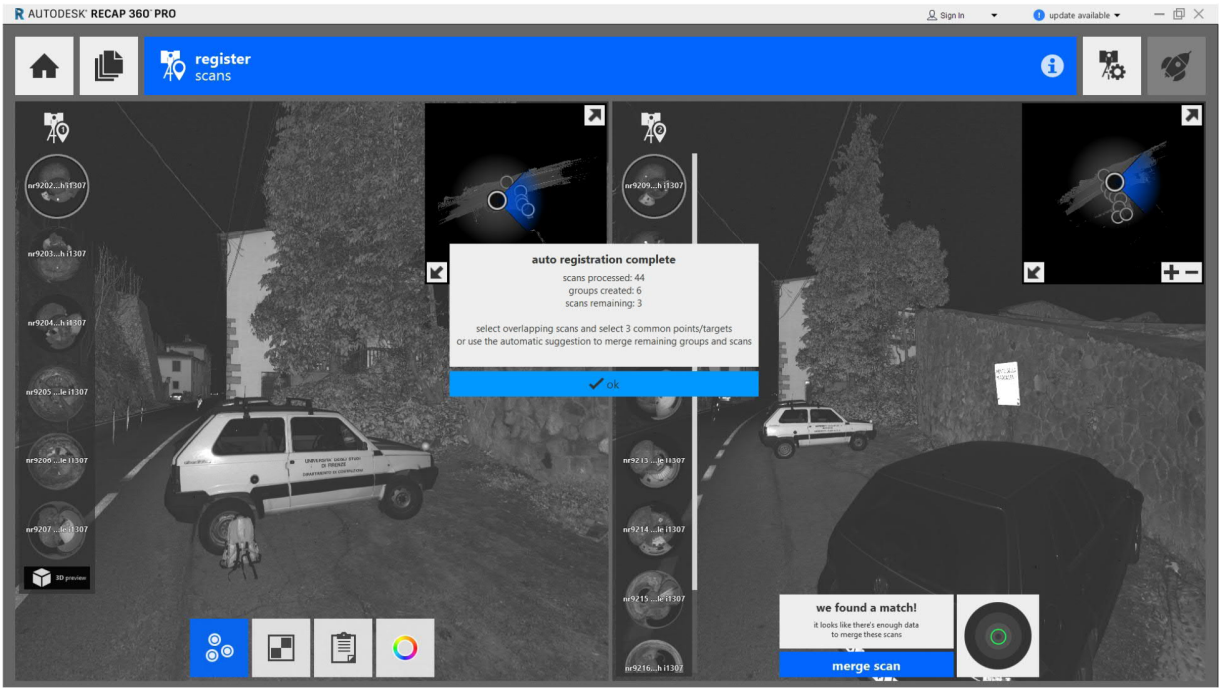


Fig. 3. Screenshot of Autodesk ReCap Pro. Scans registration

WORK MANAGEMENT ON *REALITY CAPTURE*

The working procedure on *Reality Capture*[6] is the same as other photogrammetric software like *Photoscan*[7]. In the first analysis, after having imported the point cloud and the photographs of the survey campaign, it is necessary to align it by identifying corresponding points both on the point cloud and on the photos that will subsequently be projected onto it. The next step is the reconstruction of the 3d model and finally the application of the texture. The procedure does not change with respect to *Photoscan* because it is always a procedure on a geometric basis: a point is obtained from three positions with different radius. (Fig. 5).

Another advantage is that *Reality Capture* has a faster algorithm both in data management and in physical computing.

[6] https://www.capturingreality.com/
[7] https://www.agisoft.com/

RESTITUTION

Thanks to the processing and comparison of the data of the survey campaigns carried out, it was possible to investigate and create a solid base for graphic restitution of the architectural survey of the Maddalena's Bridge, which can be used in the following ways:

Vector: Creation of a two-dimensional and easily readable, quotable and highly accurate DWG file (the survey has an instrumental error of 4mm). This is necessary and essential for the development of restoration projects and/or new constructions, for the archiving of the state of the places, and cataloging and structural interventions.

Photogrammetric: Non-invasive economic technique that provides rapid results and high detail. It is very interesting for a possible analysis of the materials, research of injuries and damage to molds, storage of the color data and the different warping of the materials.

Three-dimensional model: Three-dimensional processing performed through the comparison of the laser and photogrammetric data has allowed us to obtain a three-dimensional textured model, or with a real photographic correspondence, of possible application in various fields of use. It is the most advanced and usable cognitive method as it is possible to create interactive animations to be used on site or via the web and print easily three-dimensional models.

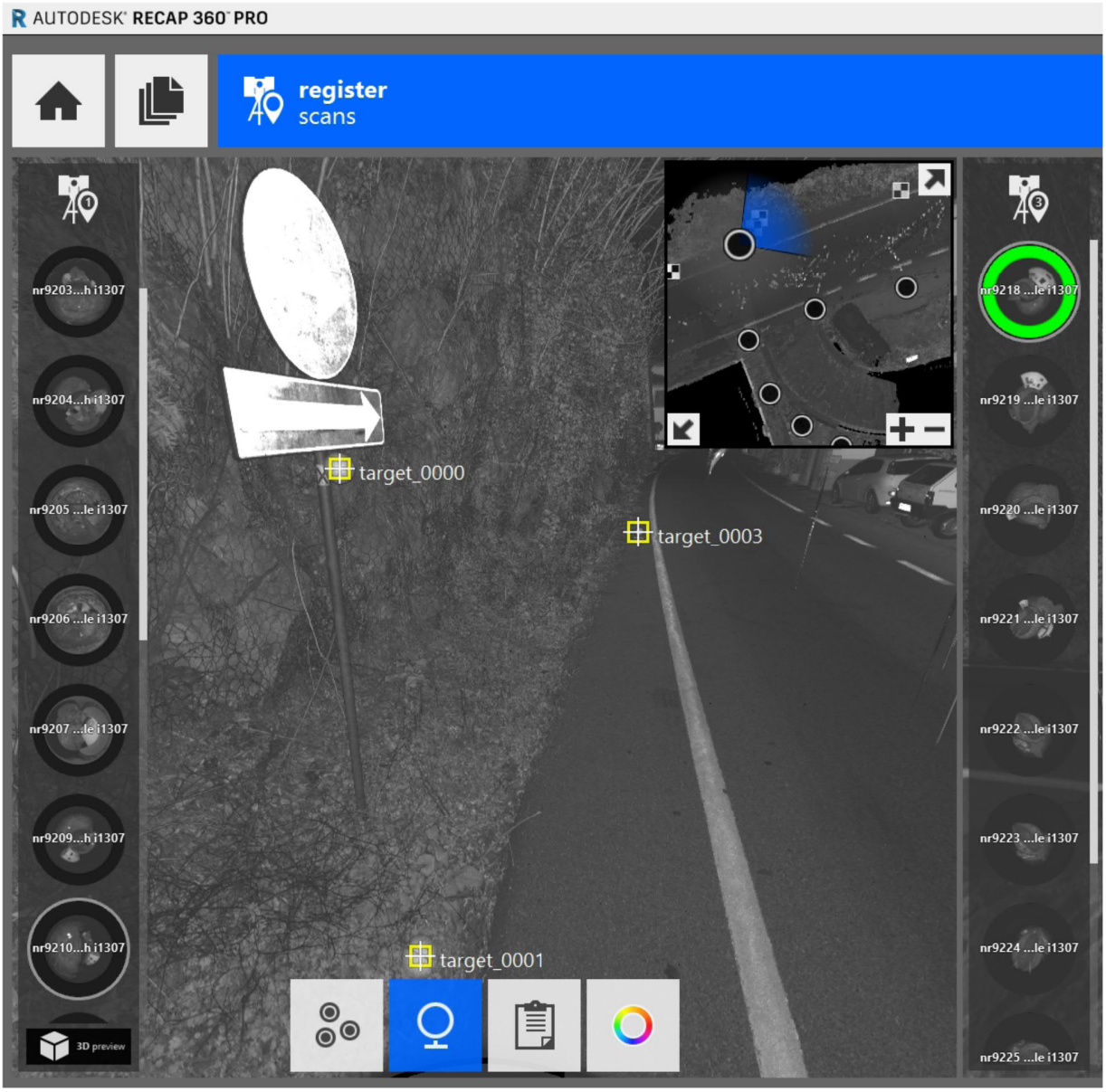


Fig. 4. Screenshot of Autodesk ReCap Pro. Target detection

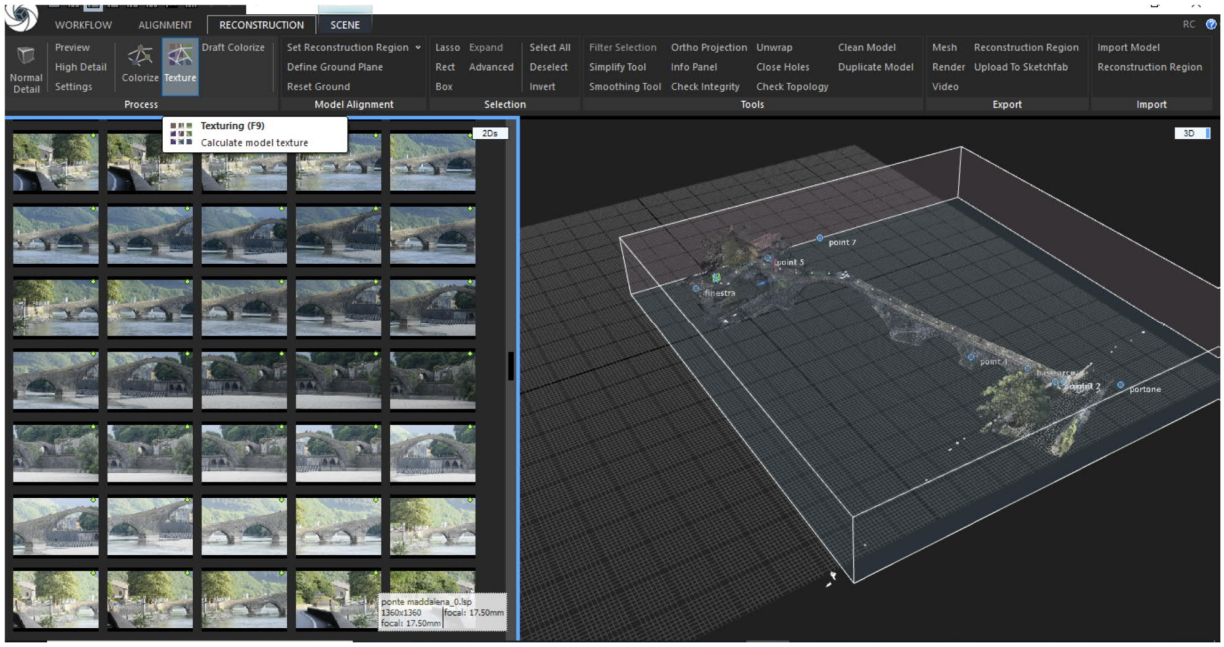


Fig. 5. Screenshot from Reality Capture. Three-dimensional model with applied photographic texture

AUGMENTED AND VIRTUAL REALITY: A NEW METHOD OF KNOWLEDGE WITHIN EVERYONE'S REACH

Thanks to the optimization of the three-dimensional model through *Reality Capture* it was possible to investigate a new aspect of the use of the survey data.

The question we initially asked ourselves was: how is it possible to make the results obtained easily and easily accessible? And how, these, can they add an element of value to the studied monument?

A logical consequence of this reasoning has led us to investigate the approach of augmented reality and virtual reality, now available to everyone as supported by the increasing technological advancement of the devices that are part of our lives.

HOW DOES IT WORK

"Augmented Reality" (AR)[8] is a technology that has been growing in interest and development in recent years. It is possible to define it as an enrichment of the observed reality through the overlay of information, contents and virtual objects in real time. Augmented reality is not to be confused with virtual reality; while in the latter the whole observed scene is entirely virtual, in the augmented reality a lot of attention is required in the research of the three-dimensionality of the environment with respect to the observer (or the capture instrument) to position the virtual object in coherence with the reality. Augmented reality allows adding artificial elements to the scene observed in real time by the person. To be able to add this virtual information it is of fundamental importance to be able to define the position of the observer in the observed scene. It makes it possible to make artificial objects one with the real scene and not make them look randomly glued. The augmented reality is generally divided into two types: Marked-based or Marker-less. Marked-based augmented reality focuses on the recognition of an object of known form (target or marker) to be able to identify the position and orientation in the environment and its perspective with respect to the eyes of the observer. Pointing the device used on a marker, its shape is obtained, through image processing algorithms. By comparing how the object was acquired with its original form, a formula is determined that describes how the object has been deformed from perspective. The user must always be careful with positioning

[8] http://www.augmentyourjourney.altervista.org/

himself correctly in front of the marker so that the whole surface is framed by the device and is not hidden by any object.

Several technologies are used in the rendering of augmented reality. You can generally classify in:

• Optical projection systems and monitors

• Portable devices

• Wearable display systems

Portable devices, such as smartphones and tablets, are the most used tools in this technology. The advantage of being available to all users, the presence of both the acquisition tool (camera) and playback (screen), the orientation through advanced sensors such as GPS and gyroscope and mobility have allowed an investment of augmented reality in this technology.

AUGMENTED REALITY AND VIRTUAL REALITY IN MADDALENA'S BRIDGE

In this specific case study, we decided to use Marked-based technology for the benefit of greater monument usability: in this way anyone can view the exact and truthful reproduction of the Bridge without having to go to the place where it is located;

However, those who are already observing the monument live will be able to enrich their experience with more information.

Operation by the user is very simple and intuitive:

In the first case, thanks to the use of a target chosen by us, the observer will only have to frame the image through smartphone or Tablet in order to view and manage the three-dimensional navigable model of the bridge that will appear exactly on the marker we inserted into processing phase.

In the second case, however, temporary and / or replaceable markers were designed to be inserted along the path that follows the devil's bridge. These do not affect the monument as easily dismantled and constantly updated, and even in this case just a simple smartphone to frame the target and get simple and immediate information on the monument.

The application we have used is *Augment*[9], an evolving online platform that allows the storage of three-dimensional models online to be used with or without marked-based technology. Once the three-dimensional model was elaborated (in our specific case, we exported the three-dimensional model texturized by *Reality Capture*), it was sufficient to upload to the platform and match the two-dimensional image that would later become the target for the model itself. Once you have done these steps, simply open the smartphone or tablet app to resize the three-dimensional object as you wish. Once saved, the model is public and available to anyone. Another interesting and well-developed application is *Sketchfab*[10]. *Sketchfab* presents itself as a Social Network for sharing 3D models; more than 600,000 3D elaborations are currently organized within it. *Sketchfab* presents a graphics engine much more powerful than *Photoscan* and this allows characterizing many aspects of our model and, above all, of its textures. Down largely used by private companies dedicated to the use of cutting-edge digital technologies, it is an innovative and immediate solution to describe and communicate the historical heritage around us.[11]

[9] https://www.augment.com
[10] http://www.sketchfab.com
[11] http://www.os-culture.org/index.php/sketchfab-tutorial

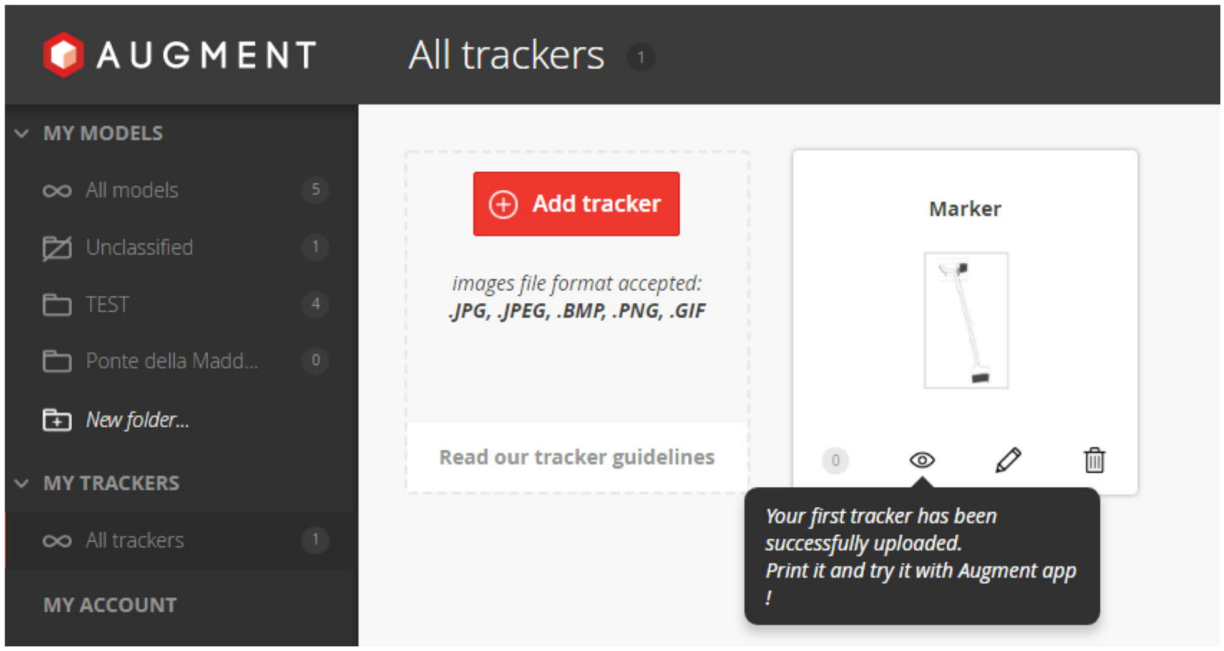


Fig. 6. Loading and matching the marker to the three-dimensional model on Augment

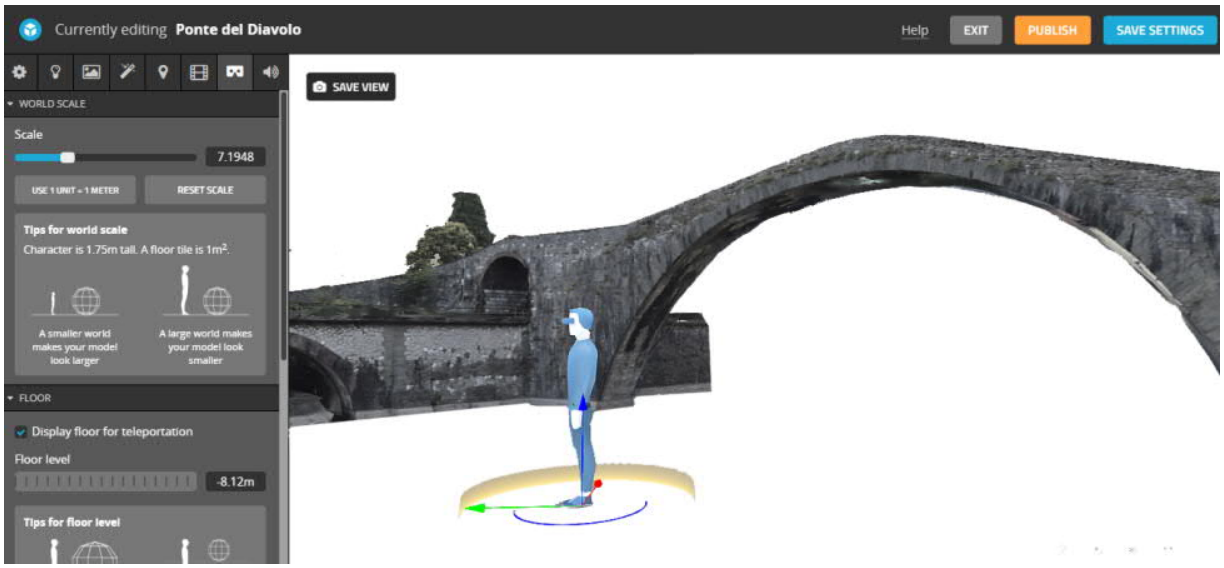


Fig. 7. Sketchfab virtual reality settings management screen. It is possible to set the observer's point of view. The representative model depicts in scale, the person who will wear the device for "Virtual Reality" (VR). So, it is possible, with reference to our three-dimensional model, to choose the scale of the subject, the position within the model, and the view.

Here it is taken into analysis as it allows to interact with the three-dimensional model through virtual reality. The three-dimensional model loaded here, made public and available to all the members of the platform, can be integrated with knowledge boxes where it is possible to add information about the model itself. Once loaded, it is possible to set the parameters to make it viewable through the use of wearable VR glasses, (also strictly economic,

such as *Google Cardboard*[12]), which allow the use of the totally immersive model. A final consideration is on the choice of platforms used. We have used services provided by third-party organizations, such as *Augment* and *Sketchfab*, to have a quick result both in terms of virtual modeling and in terms of use by the customer, tourist or simple user. They are platforms that offer both free services and additional paid services (for example *Sketchfab* imposes a maximum limit of 50 mb in upload), even if both support an unlocking of paid services or a facilitation for educational purposes. Despite the possibility of using others software, such as *Unity*[13] that does not involve the presence of third parties, our choice has remained to use these operators to greatly facilitate access to this information both by the average user, who through smartphones, tablets and other devices of medium-low range, so as to be available on a large scale.

FINAL CONSIDERATIONS

The study, analysis and survey carried out by Maddalena's Bridge, or Devil's Bridge, have allowed us to obtain a high level of knowledge of the building, which can be used both from a technical and historical point of view. But this study does not want to limit itself only to the single specific case taken in analysis. It wants to propose itself as a basis for a broader reflection on the methodologies of the survey: on the one hand regarding the use of software that, after overcoming the obstacle of the precision of analysis, also allow an optimization of the working times. On the other, it wants to be a starting point for a functional and fruitful integration of new technologies, whose exponential evolution cannot be kept marginal from our field of study.

ACKNOWLEDGEMENTS

Special thanks go to the Photographic Laboratory of DIDALABS System (Dipartimento di Architettura, University of Florence) for the participation to the survey campaigns and the assistance during all the shooting and post-processing activities.

REFERENCES

Natale Gucci, Anna de Falco, and Maria Pacini Fazzi (Eds.). 2010. Il fascino e la funzione, Il ponte della Maddalena, detto del Diavolo.

Emanuele Repetti. 1843. Dizionario Geografico Fisico e storico della Toscana , contentenente la descrizione di tutti i luoghi del Granducato – Ducato di Lucca, Garfagnana e Lunigiana, Vol. V.

Andrea Duè. 1994. Atlante Storico della Toscana. Casa editrice Le Lettere, Firenze.

Francesco Simonetti Cenami. 2002. Tesi di Laurea. Il ponte della Maddalena detto del diavolo, storia, sicurezza, conservazione. Università di Pisa.

Guglielmo Lera. 2014. Pacini Fazzi editore. Il ponte del Diavolo. Illustrazioni e leggende,

Marco Recati. 2017. Tesi di Laurea. Il palazzo dei Vicari di Scarperia: Il rilievo digitale come base per nuove letture di un patrimonio costruito.

Lorenzo Piangiani. 2018. Built Heritage and B.I.M. Il palazzo di Francesco nella “Fortezza Vecchia” di Livorno compie un secondo passo nell’era digitale.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz

[12] https://arvr.google.com/cardboard/
[13] https://www.unity3d.com

Fig. 8. The poster presented to CHNT Conference, November 2018

Rollout Archaeological Photography for the Graphic Documentation of Cultural Heritage

ÁNGEL M. FELICÍSIMO, MARÍA EUGENIA POLO and GUADALUPE DURÁN DOMÍNGUEZ, Universidad de Extremadura, Spain
TRINIDAD TORTOSA, Instituto de Arqueología de Mérida, Consejo Superior de Investigaciones Científicas, Spain
ALICIA RODERO, Museo Arqueológico Nacional, Spain

Peripheral or rollout photography is a non-destructive technique designed to “unroll” the surface of an object in order to represent it on a flat surface and to obtain a more comprehensive and continuous view of the object’s decorative motifs. This technique is especially useful when applied to cylindrical objects. Recently, this process has been simplified with the advent of digital photography. Today, it is not only possible to use conventional cameras, but also to work with filters and digital treatments that go beyond the traditional photo. Digital rollout imagery in archaeology provides the opportunity to visualize decoration completely, thereby providing detailed analysis and documentation by allowing for the integration of the iconographic content of three-dimensional structures with decorations on all sides, shown by the same two-dimensional aesthetic narration. This work will present the methodology used to obtain high-resolution rollout images considering all of the technical aspects from the photo shoot through to digital processing. In addition to highlighting issues that have not always been accurately addressed, such as color calibration, we will show our own development techniques to merge and "unroll" the images. Finally, we will explain how the application of specific filters (such as DStretch) can reveal aspects of decoration that are not clearly visible in the conventional image, improving its documentation and thereby providing a thorough reading for the study of these collections. This process will be applied to the so-called “The Warriors´ Cup” of Archena, a large Iberian *kalathos* from the Hellenistic period decorated in ochre tones, which is currently on display at the National Archaeological Museum of Madrid.

Key words:
Digital photography, Graphic documentation, Rollout photography.

CHNT Reference:
Ángel M. Felicísimo et al. 2018. Rollout Archaeological Photography for the Graphic Documentation of Cultural Heritage.

INTRODUCTION

Archaeological photography is intended to provide accurate and reliable graphic documentation of archaeological objects, considering that the images must preserve all of their dimensional and chromatic properties. There are several techniques to enhance and improve the final results in order to give users a better understanding of the archaeological object, and to graphically document our cultural heritage. One of these techniques is called rollout photography.

Peripheral or rollout photography is a technique that aims to “unroll” the surface of an object in order to represent it on a flat surface and to obtain a more comprehensive and continuous view of the decorative motifs. The purpose is to obtain a flat view with minimum geometrical distortion of cylindrical vases, jars or similar archaeological objects [Felicísimo 2011] with the consequent advantage of visualizing all of the information contained in the object in a single panoramic photograph.

Authors addresses: Ángel M. Felicísimo, Department of Graphic Expression, University of Extremadura, Avda. Santa Teresa de Jornet, 38, 06800 Mérida (Badajoz), Spain; email: amfeli@unex.es ; María-Eugenia Polo, Department of Graphic Expression, University of Extremadura, Avda. Santa Teresa de Jornet, 38, 06800 Mérida (Badajoz), Spain; email: mepolo@unex.es ; Guadalupe Durán-Domínguez, Didactics of Musical, Plastic and Body Expression, University of Extremadura, Avda. Santa Teresa de Jornet, 38, 06800 Mérida (Badajoz), Spain; email: gldd@unex.es ; Trinidad Tortosa, Instituto de Arqueología de Mérida, National Research Council, Plaza de España, 15, 06800, Mérida (Badajoz), Spain; email: tortosa@iam.csic.es ; Alicia Rodero, Museo Arqueológico Nacional, Serrano, 13, 28001 Madrid (Spain) ; email: alicia.rodero@mecd.es

Rollout photography was developed in the mid-twentieth century using analogue photography, and was further developed in 1970 when Justin Kerr made a series of hundreds of rollouts of Mayan vessels[1]. This vase database offers information about each vase (such as its type, size, and owner) and makes it possible to visualize both the image of the original object and the rollout image. Historical information can be accessed in [Davidhazy 1986; Kerr 2007].

This process has been simplified using digital photography because it allows working with more filters and digital treatments than traditional photo.

In addition to rollout photography, there are other techniques that make it possible to explore in even greater detail the information contained in the digital image of an archaeological object, for example, by applying specific filters that can reveal aspects of decoration that are not clearly visible in the conventional image.

The aim of this paper is to explain the workflow of two specific techniques applied to archaeological photography: rollout photography, and the application of filters to highlight pigments and to enhance colours. The study case will be a cylindrical Iberian cup decorated with a continuous frieze around the vessel. This cup has been chosen because of its geometric characteristics and its pigments.

MATERIAL

The Warriors' vessel was found in a necropolis in Archena (Murcia, Spain) [García Cano and Page 1990]. This vessel is 41 cm high with a maximum diameter of 36 cm, and has been dated to the third century B.C. It is in the Museo Arqueológico Nacional of Spain (reference 1918/69/1). The frieze around the center of the vessel shows different scenes of warfare: a duel between foot soldiers, a clash between a foot soldier and a cavalryman, and another cavalryman who is riding with his lance to provide support. These episodes are watched by animals, such as a wolf and several wild boars, all of whom are involved and included in this story. A unique element in Iberian iconography found on this vessel is the presence of injured or wounded figures in the bottom part of the frieze: some of them are even shown still pierced by the lance that killed them. The warriors, shown wearing belts, carry different weapons such as the *falcata*, lance, or oblong shields (Fig. 1) [Tortosa and Santos 1997; 1998]. It is thought that the vessel was used as a container for the cremated remains of the deceased. In brief, this large vessel features one of the best known and unique Iberian iconic narratives [Tortosa 2006]. The vessel is currently on display at the National Archaeological Museum of Spain (Reference 1918/69/1).

The importance of this technique for historians not only lies in the fact that it makes it easy to see a continuous image of the pictorial frieze, but also in that despite the deterioration it suffers, it can be preserved for future generations.

As the cup has a cylindrical shape and shows figures in a continuous frieze around the vessel, it is a perfect object to be photographed using the rollout technique [Felicísimo et al. 2017].

The photographs were taken with a Pentax 645Z camera (51 Mpx) with a 120 mm Pentax calibrated lens. The additional material used included NanGuang bicolour LED panels (CRI > 92), a manual turntable, a Manfrotto tripod to prevent camera movement, an external photometer Sekonic L-308S, and an X-Rite card for color calibration. It was not necessary to use a polarizing filter as the vessel has a matt finish.

Fig. 1. The Warriors' vessel (National Archaeological Museum of Spain) (Ref. 1918/69/1)

[1] http://www.mayavase.com/

Several software applications were used to complete the rollout process and to apply filters to enhance the pigments and colors:

Adobe Photoshop is a commercial software used for image editing, digital art and graphic design. Adobe Photoshop is used for the basic processing of RAW images into TIFF format. This process includes the importing (Adobe Camera Raw), color balance and calibration processes, and image cropping. A free alternative option is GIMP[2].

The image fusion was carried out using Microsoft ICE[3], a free software that makes it possible to choose different projections of the results. Other options are PTGui[4], Panorama Factory[5], or Hugin[6].

Finally, DStretch is a plugin for the free software programme ImageJ[7] created by Jon Harman. Dstretch includes several image enhancement techniques.

METHODOLOGY

The procedure involves two separate stages; the first consists of creating the rollout photograph, and the second consists of applying specific filters to enhance the decorative motifs.

To create the rollout photograph, the object is placed on a turntable so that it can rotate on its axis. The optical axis of the camera must be horizontal and point to the axis of rotation, in the center of the vessel. A series of overlapped photographs is taken by rotating the table at regular intervals so that each of them picks up the central part of the object and overlaps them with the previous and subsequent shots. Usually, the shots must complete a full rotation around the object. Some complementary technical issues about the image captures are:

- ISO sensitivity was set to the minimum value (100) so as not to add electronic noise. Since the camera is on a tripod, using longer shutter speeds is not a problem.
- The diaphragm value was set to 11. Values f:8 to f:11 are the ones that offer maximum acutance in the images and present the minimum values of distortion and chromatic aberrations (these values must be determined beforehand by means of specific tests). In addition, it guarantees that the depth of field is sufficient for the area of interest of the vessel to be focused.
- The measurement of light has been made by means of an external photometer.
- To reduce trepidation, the shooting mode is in two steps: mirror rise and shooting. The camera is triggered remotely, either by cable (preferred method for us) or with an infrared remote control.
- Images are captured in RAW format (DNG, 14 bits), providing a large amount of radiometric information.
- The distance between the camera and the object should be as small as possible to cover as much of the sensor and achieve the highest possible spatial resolution.

The shots are corrected for colour bias and by transforming the image from RAW to 16-bit TIFF format using Adobe Camera Raw or similar software and a specifically generated color profile from the color chart. In this case, a total of 36 images were taken with a rotation of 10º between each image. The degrees of rotation and the number of shots depend on the vase radius to ensure the minimum distortion value in the central part of the image.

Each photograph is trimmed to the same size using a rectangular frame, maintaining the same height and only conserving the part to be "unrolled" as well as the overlapping areas between consecutive images (Fig 2). It is necessary to trim the images in order to eliminate the areas with higher distortion on the edges of the image. In general, only one third of the photograph is preserved. The stage is performed with image- processing software as GIMP (open source) or Adobe Photoshop (commercial).

[2] GNU Image Manipulation Program, https://www.gimp.org/
[3] Image Composite Edition, https://www.microsoft.com/en-us/research/product/computational-photography-applications/image-composite-editor/
[4] commercial, https://www.ptgui.com/
[5] commercial, http://www.panoramafactory.com/
[6] free and open source http://hugin.sourceforge.net/
[7] https://imagej.nih.gov/ij/ available from http://www.dstretch.com/

Fig. 2. Each photograph is trimmed to the same size using a rectangular frame, maintaining overlapping areas between consecutive images

The next step is to fuse the images into a single image by aligning and merging individual shots supported by overlapping areas. The software automatically searches for tie points, corrects distortion and creates a unique image as the output (Fig. 3).

The final image, with balanced color, contrast and luminosity, can be added to the documentation of the archaeological object. There are complementary techniques that can be used to solve specific problems, such as diffuse lighting or cross polarization, macro photography, or color calibration.

Although the used technique may seem similar to SfM (Structure from Motion), the objective and process are different. SfM aims at the construction of 3D models by photogrammetry from 2D images [Remondino et El-Hakim 2006; Remondino et al. 2014]. Rollout technique aims merging 2D images to generate a global 2D image as a cartographic projection. Both are different in software tools, process, involved statistics and results. In any case, the images taken for SfM process may be useful for rollout if this has been anticipated in the shooting planning.

The second proposed procedure is the application of the DStretch filter (a plugin for the free ImageJ software) originally developed for processing images of prehistoric rock art. DStretch performs a decorrelation stretch on color images [Alley 1996]. Decorrelation stretching is an image processing technique, first used in remote sensing, that enhances the color separation of any image removing the correlation found in RGB image bands and equalizing the variances. The calculation produces a 3x3-transformation matrix that is then applied to the RGB bands colors in the original image to project them on different color axes. The new image enhances the colors and can improve the visual interpretation and make feature discrimination easier but the effectiveness of each transformation is little predictable and all the options must be tested to choose the right one. DStretch supports several own color spaces: YDS, YBR, YBK, LDS, LRE... that are modifications of the conventional YUV or LAB color spaces, and includes the possibility of designing own color spaces [Harman 2015]. Fig. 4 shows the image of the Warriors' vessel and the same image after applying the LDS transformation. LDS is described as a general purpose enhancement that emphasizes the yellow and ochre-colored traces. The result is that decorative motifs are highlighted, and make it possible to see the picture, vessel, or any decorated objet from a new perspective.

RESULTS

All of the operations explained in the methodology section to create rollout photography result in the full image shown in Fig. 3. This image has a slight geometrical distortion resulting from cylindrical vases with all the

information contained in the object in a single panoramic image. The size is 11522 x 3443 pixels and the resolution is approximately 0.1 mm/pixel.

Fig. 3. Final image obtained from the rollout process (11522 x 3443 pixels)

This image can be processed to try to enhance the colors using DStretch (see Methodology). Fig. 4 shows the result of applying the LDS filter to a single image and Fig. 5 shows the result using the rollout image, which seemingly provides more visual information than Fig. 3.

Fig. 4. D-Stretch filter applied to a single image of the Warriors´ vessel

All of the figures are enhanced, and it is easier to analyze the details of the decoration. Finally, a LDS filter has been applied to the images to generate a 3D model by means of Agisoft Metashape. This is a procedure where the original images are replaced by those processed with the model already built, which avoids the need to perform photogrammetric calculations again. The result[8], although not the objective of this work, effectively complements the rollout method and extends the usefulness of DStretch color transformations.

[8] https://skfb.ly/6NuTw and https://skfb.ly/6NuT9

Fig. 5. LDS algorithm of D-Strech applied to the final rollout image

The authors think that the quality of the textures of the 3D models by SfM is worse than the ones got with the rollout method, both in resolution and color fidelity. Rollout can use very large images without needing large computer resources because the underlying process is much simpler than in the case of 3D techniques. Textures from the 3D models typically have a few tens of megabytes while those used for rollout can be much larger. In this example images with 51 Mpx images were used to have a good resolution and the resulting image has a size of 165 Mb. Building a texture of this size using SfM is, in the authors' opinion, unsuitable. Moreover, the "development" of an object from the 3D model to a projected flat image is not a procedure foreseen in SfM programs. With regard to the quality of the color, we have done some analysis on the quality of images or textures from SfM. The results show that the textures do not have good color fidelity, especially the dark tones (i.e. bronze objects). The reason is that the SfM software (we use Agisoft Metashape) does not includes specific color management procedures, as the Adobe Photoshop or other professional photo editors. We are currently working on a procedure for the control and improvement of color in photogrammetric 3D models, one of whose objectives is to locate the critical points where color is distorted and look for an alternative.

CONCLUSIONS

Several photographic techniques are available that make it possible to improve the graphic documentation of the cultural heritage.

Rollout photography is a technique that makes it possible to 'unwrap' the information contained in a cylindrical vase with minimum distortion. The use of appropriate photographic techniques helps to achieve a high-quality final product, both in spatial resolution, color fidelity, and acutance.

The use of digital rollout imagery in archaeology offers the opportunity to completely visualize the decoration of objects, thereby providing detailed analysis and documentation by allowing for the integration of iconographic content of three-dimensional structures with decorations on all sides, shown by the same two-dimensional aesthetic narration

Moreover, the application of specific filters (such as DStretch) can reveal aspects of the decoration that are not clearly visible in conventional images, thereby improving the graphic documentation of cultural heritage.

ACKNOWLEDGEMENTS

This work is part of Project HAR2017-87897 financed by the Spanish Ministry of Economy, Industry and Competitiveness.

REFERENCES

Ronald E Alley. 1996. Algorithm Theoretical Basis Document for Decorrelation Stretch. Jet Propulsion Laboratory, Pasadena, CA 91109 (1996) 18.

Andrew Davidhazy. 1986. Principles of peripheral photography. *Ceramics Montly Magazine*, 34,2 (1986), 48–50.

Ángel M. Felicísimo. 2011. Vase rollout photography using digital reflex cameras. *Technical Briefs in Historical Archaelogy*, 6, (2011), 28–32.

Ángel M. Felicísimo, María-Eugenia Polo, Trinidad Tortosa, and Alicia Rodero. 2017. Iberian notebooks in 3D. Observing and interpreting: the Iberian world of the Museo Arqueológico Nacional in 3D. (2017), 28.

J.M. García Cano and V. Page. 1990. La necrópolis ibérica de Archena. Revisión de los materiales y nuevos hallazgos. *Verdolay* 2 (1990), 109–148.

Jon Harman. 2015. Using DStretch for rock art recording. *INORA - International Newsletter on Rock Art*, 72 (2015): 24-30.

Justin Kerr. 2007. A short history of rollout photography. The Kerr collections, Foundation for the Advancement of Mesoamerican Studies, Inc. http://www.famsi.org/research/kerr/rollout.html . Accessed 08 February 2019

Fabio Remondino and Sabry El-Hakim. 2006. Image-based 3D Modelling: A Review. *The Photogrammetric Record*, 21(115) (2006), 269-291.

Fabio Remondino, Maria Grazia Spera, Erica Nocerino, Fabio Menna, and Francesco Nex. 2014. State of the art in high density image matching. *The Photogrammetric Record*, 29(146) (2014), 144-166.

Trinidad Tortosa. 2006. Los estilos y grupos pictóricos de la cerámica ibérica figurada en la Contestania. CSIC. 244.

Trinidad Tortosa and J.A. Santos. 1997. Orígenes y formación de la colección de vasos pintados de Elche-Archena en el Museo Arqueológico Nacional. Boletín del Museo Arqueológico Nacional XV, nº 1 y 2 (1997): 49-57.

Trinidad Tortosa and J.A. Santos. 1998. Los vasos pintados de Elche-Archena en el Museo Arqueológico Nacional: análisis tipológico e iconográfico. Boletín del Museo Arqueológico Nacional, XVI, nº 1 y 2 (1998): 11-63.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz
The editor's office is not responsible for the linguistic correctness of the manuscripts.
Authors are responsible for the contents and copyrights of the illustrations/photographs.

Advanced Documentation Methods in Studying Corinthian Black-figure Vase Painting

STEPHAN KARL and PAUL BAYER, University of Graz, Austria
HUBERT MARA, Heidelberg University, Germany
ANDRÁS MÁRTON, Centre de recherche bretonne et celtique, France

Unwrappings are crucial in archaeological pottery studies. Within the study of Greek pottery, unwrappings of painted surfaces have a long tradition and their significance is still well-deserved. They show the depiction without photographic distortions or partitioning in multiple photographs, enabling archaeologists to analyse and interpret the image as a whole. This is especially true in the case of Corinthian pottery, where the poor preservation of the painting tending to flake off often results in unclear photographs. Nevertheless, traces of flaked off painting layers are still visible on the surface under specific illumination. Creating unwrappings manually is time-consuming. Manual acquisition with tactile tools like tracing paper is often not allowed due to the fragile nature of the surfaces. To facilitate this task for pottery archaeologists, a combination of 3D data derived by "Structure-from-Motion" (SfM) and "computed tomography" (CT) is proposed, where each technique can also be on its own. The fusion of these data sources to exploit their specific strengths is a new approach in the field of "Cultural Heritage" (CH): SfM with a high resolution in texture and CT with a high accuracy in geometry. The SfM and CT data are combined by transferring colour information to the vertices of the CT model. Afterwards, the GigaMesh Software Framework was used for enhancing geometric features in the surface data, in this study case, the fine incisions of the black-figure painting. With this approach, accurate and sufficiently detailed unwrappings aligned to the needs of pottery specialists can be created in minimum time.

Key words:
Computed tomography, Texture mapping, Corinthian pottery, Vase painting, Feature vectors, Unwrapping.

CHNT Reference:
Stephan Karl et al. 2018. Advanced documentation Methods in Studying Corinthian Black-figure Vase Painting.

INTRODUCTION

Unwrappings of curved painted surfaces are essential elements of a scientific documentation of an object in archaeological pottery studies. Within the study of Greek pottery, these unwrappings have a long tradition and a well-deserved high significance [Walter 2008]. They show the image without photographic distortions or partitioning in multiple photographs due to the partially or completely circumferential painting. This enables archaeologists to analyse the image as a whole in terms of style, dating and depiction. Additionally, such unwrappings transform the painting in a clearly legible graphic execution highlighting relevant details for the stylistic analysis. This is especially true in the case of the Corinthian black-figure pottery, where the poor preservation of the black glaze tending to flake off often results in unclear photographs. Black-figure describes in archaeology a Greek vase decoration technique, in which figures and ornaments were painted as silhouettes before a light background, using black glaze, whereas inner details were incised into the painted layer and specific areas were highlighted using added colours [Amyx 1988]. Thus, in computer science terminology the black-figure painting consists of texture and geometry data. In some cases of the Corinthian pottery where the painting is completely worn off, only the incisions are left. Nevertheless, traces of flaked off painting layers, like "shadows", are mostly still

Authors addresses: Stephan Karl and Paul Bayer, Institute of Archaeology, University of Graz, Universitätsplatz 3, 8010 Graz, Austria; email: (stephan.karl, paul.bayer)@uni-graz.at; Hubert Mara, Interdisciplinary Center for Scientific Computing, Heidelberg University, Im Neuenheimer Feld 205, 69120 Heidelberg, Germany; email: hubert.mara@iwr.uni-heidelberg.de; András Márton, Centre de recherche bretonne et celtique, Chercheur associé, 18, rue Guerin, Bât. C. 94220 – Charenton-le-Pont, France; email: saxamus@gmail.com

visible on the surface under specific illumination. They allow archaeologists to reconstruct the painting and to perform unwrappings with reasonable certainty. The importance of unwrappings for stylistic analysis in Corinthian pottery, for identifying closely hands and workshops of Corinthian painters, is be underlined by recent works [Neeft 1998; 2013; 2017]. These are necessary stages to obtain a fine dating of the artefact and its context and for studying trade patterns or Corinthian craftmanship for example.

Although widely applied in archaeological pottery studies, there are barely any detailed descriptions of this process. A good example can be found in Hall [1936]. For making unwrappings one uses a tracing paper with highest possible transparency and with a rough surface for executing lines as thin as possible. The first challenge is to keep the tracing paper on the surface without displacements. This is achieved either by one hand whereas the other draws or by a strong band of elastic girdling the vase. If the surface is badly worn, which can be often the case in Corinthian pottery, only some glazed areas and some incisions can be seen accurately enough through the tracing paper. In such cases a careful examination must be made using a magnifying glass, while placing and removing the tracing paper several times and completing the tracing in front of the vase. The second challenge is to transfer a curved surface not based on a geometrical shape as cylinder or cone into the plane. In Corinthian pottery, the most emblematical and one of the most numerous vase shapes as aryballoi with a spherical shape and alabastra with an ovoid shape cause inevitably some distortions when projected to a plane. Such surfaces are called non-developable in mathematics. While unwrapping pottery surfaces, one principally avoids distortions of figures and tries to shift all necessary increases in the background (the area between the figures), making as little change in the composition as possible. This is done manually by shifting the tracing paper accordingly. However, there are scenes where single figures are linked together in close figural compositions, but also when the filling ornaments are tightly following the contours of the figures covering densely the background in a tapestry-like effect [Amyx 1988]. In these cases, one has to distribute the distortion even and reasonable. At the end, the tracing is transferred to a final drawing. The lines of the tracing, often feeble and inaccurate, must be strengthened and corrected in front of the vase.

The realisation of manually created unwrappings is a highly time-consuming task. A major obstacle is that using tactile tools like tracing paper is often not allowed by museum curators and conservators due to the fragile nature of the surfaces. Furthermore, one needs a trained person with necessary illustrative skills. An imprecise unwrapping is at least useless but can also be seriously misleading. Additionally, the manual drawings have to be digitised in an adequate way for the final publication, mostly using graphic programs, which also takes some time.

Within the history of the *"Corpus Vasorum Antiquorum"* (CVA), the international standard publication of Greek pottery, there was an attempt in the mid-1960s to realise unwrappings using traditional photographical technology [Villard 1965]. For this, a special experimental camera was designed. Even if considerable distortions occurred around the upper and lower edges, it brought excellent results in case of the well-preserved vases. However, the technological difficulties prevented this slow and laborious method to be adopted by the scientific community.

Therefore, to facilitate this task for pottery archaeologists and to overcome the above-mentioned difficulties, we propose the application of already existing computer-assisted methods performing rollouts and to use these rollouts combined with feature enhancements to create a final drawing aligned to the archaeological purposes. Such rollouts obtained from a 3D model have two main advantages: (i) their acquisition is contact free and (ii) the results are verifiable and repeatable. A basic precondition is to capture the black-figure painting with its fine texture and incisions and to achieve a high quality for the post-processing and analysis. For this, we have chosen a fusion of 3D data derived by "Structure-from-Motion" (SfM) and "computed tomography" (CT). It exploits the specific strengths of these not-contact digitisation techniques: SfM with a high resolution in texture and CT with a high accuracy in geometry.

RELATED AND PREVIOUS WORKS

Technologies for acquiring 3D data, for performing geometric analysis and for visualisation in "Cultural Heritage" (CH) applications have become a broad research topic [Pintus et al. 2016]. Generating rollouts of rotation-symmetric objects represent an important computational tool for enhancing perception. It was applied on cylindrical seals [Pitzalis et al. 2008; Dahl et al. 2018] or on pottery with curved vessel profiles using frustum-shaped cones or clipped off spheres as proxy geometry [Bechtold et al. 2010; Mara and Portl 2013; Rieck et al. 2013]. The last-mentioned methods are implemented in the open access GigaMesh software framework[1], freely available with video

[1] https://gigamesh.eu

tutorials[2]. Conical and cylindrical rollouts can also be created e.g. using CloudCompare[3] [Nocerino et al. 2018] or TroveSketch[4] [Hörr 2011; Hörr et al. 2011]. However, all these methods create rollouts which are still 3D models in contrast to a manually created unwrapping.

"Structure-from-Motion" (SfM) or "Structured Light Scanning" (SLS) are commonly applied in pottery research for obtaining 3D data. Alongside these optical methods also CT is used to create 3D representations of objects; of course, with a specific focus on the inner structures. In generally, CT has a significant impact on the methodology of object documentation, fabric analysis, and identification of manufacturing techniques [Karl et al. 2013]. In the last years an increase of CT and microCT applications in archaeological pottery studies are to be noticed. Normally, direct volume renderings coupled with CT slices are standard, e.g. for the investigation of manufacturing techniques [Sanger 2016; Kozatsas et al. 2018] or organic inclusions within pottery sherds [Barron and Denham 2018]. Based on the segmentation of the volume data, shape analysis of pores and inclusions within the ceramic fabric represent valuable first steps in analysing CT data quantified for comparative purposes [Kahl and Ramminger 2012]. The most significant drawback of microCT scanning in pottery research and its use as non-destructive method is its sample size limited on only few centimetres. Other approaches use CT volume data gained by industrial CT scanners to reconstruct surfaces after filtering and segmentation processes [Jungblut 2012; Jungblut et al. 2013]. Transferred to a 3D mesh the object can be analysed based on the surfaces of the matrix (the ceramic body) and of the inner inclusions, e.g. calculation of the filling capacity or the fabric density [Karl et al. 2013]. The knowledge of inner structures revealed by CT has also an impact on the study of vase paintings, as demonstrated in a specific case by visualising a hitherto unknown ancient repair on a Corinthian black-figure alabastron [Karl et al. 2018].

A combination of multiple data sources of different 3D acquisition techniques as X-ray tomography, optical micro topography and photogrammetry was demonstrated by Pitzalis et al. 2008 on a cylinder seal, whereby surface noise and the deformation of the final shape using X-ray tomography mentioning in this work are obviously results of a poorly adjusted, calibrated and/or suited device and reconstruction algorithm. Up-to-date CT systems deliver precise data for accurate surface determination which is nowadays an approved method in dimensional measurements [Buratti et al. 2017].

Fig. 1. Corinthian aryballos G 26 from the Archaeological collections of the University of Graz (KFU Graz)

MATERIAL AND METHODS

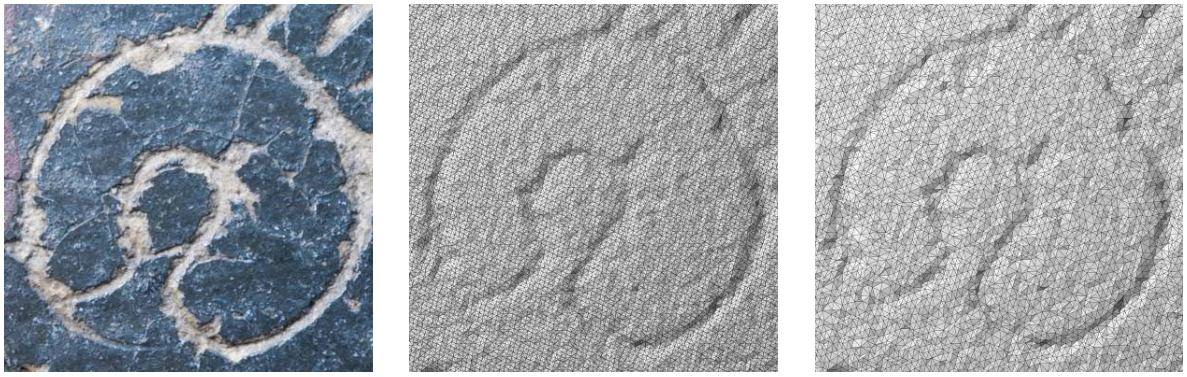
For this demonstration, a Corinthian aryballos from the Archaeological collections at the University of Graz (KFU Graz), inv. G 26[5] (Fig. 1) was used. This pottery object was published in the "Corpus Vasorum Antiquorum" (CVA) [Christidis et al. 2014]. This aryballos was primarily chosen because its background is densely filled in the way mentioned above. Vases decorated in this manner are frequent in the second half of the Early and first half of the Middle Corinthian period (c. 610–580 BC) [Amyx 1988]. The object is well preserved with only some parts of the black glaze flaked off. There were also archaeological reasons for this choice: during the research for the CVA

[2] https://gigamesh.eu/youtube
[3] https://www.danielgm.net
[4] http://www.archaeologie.sachsen.de
[5] https://gams.uni-graz.at/o:arch.2478

publication, this aryballos could not be attributed to any already identified painter or workshop. Additionally, the uncanonical filling ornaments with parallel rows of connected short arches seems to be particular and very rare to the authors best knowledge. Therefore, an accurate unwrapping of this circumferential painting should serve as a reference for further comparative stylistic analysis.

Computed Tomography

The object was scanned using a Phoenix v|tome|x L 240 X-ray cone beam CT scanner at the Austrian Foundry Research Institute[6] at Leoben. The scanner consists of a 240 microfocus kV X-ray tube and a horizontal shiftable 1-megapixel (1000 x 1000 pixels) flat panel detector. This CT device is suitable for sample sized up to 335 mm in diameter and 550 mm in height which means that almost all vessel shapes of Corinthian pottery can be scanned. The pottery object was positioned on the turntable pivoted to his rotation axis in an angle of 35° and placed on a three-point mount of "extruded polystyrene" (XPS). A maximum X-ray energy of 180 kV, 220 µA current and a 0.5 mm thick tin filter was used to scan the object, which consists of each 1500 projection images acquired over a 360° rotation in four overlapping single scans. Each projection image was acquired by average 2 and skip 1 with a detector exposure time of 200 ms. The resulting pixel size of this object with a maximum high of 9.2 cm and a maximum diameter of 8.8 cm was 55 µm. The total scan time including calibration beforehand was 129 min. The reconstruction of the projection images was performed using the software datos|x to produce a 3D volumetric data set. The cubic CT volumetric data set with dimensions in x/y/z of 1850/1850/2108 voxels has a reconstructed isotropic voxel size of 55 µm. The total reconstruction time was 44 min.



a b c

Fig. 2. Section of the aryballos KFU Graz G 26, size 5 x 5 mm: a) Photograph; b) CT surface in original resolution based on voxel size of 55 µm resulting in 564 points per 1 mm² in average (within this section); c) CT surface with point reduction within a tolerance of 0.01 mm resulting in 185 points per 1 mm² in average

The reconstruction of surface data from the volume data was performed using the commercial software VGStudio Max 3.0[7]. The surface was constructed using the local iterative surface determination implemented in this software [De Oliveira et al. 2016; Townsend et al. 2017]. It produces a material boundary based on local surrounding voxels. For compensating local deviations produced during the acquisition process, the search distance was adjusted to 7 voxels. The extraction of a surface polygonal mesh was performed using the surface extraction tool which samples the surface for the point creation using the ray-driven reconstruction modus. The resolution of the mesh was set to the voxel size. The result was exported as STL file. Reduced from some erroneous mesh parts of the supporting material and transformed to a PLY file, the resulting mesh has a point density of 499 points in average on 1 mm² of the object surface (matrix and pores), consisting of 30.742.039 vertices and 61.328.498 faces (Fig. 2b).

To make this data easier to process, the point reduction tool was used. The original point cloud was reduced by the elimination of points lying within a distance of 0.01 mm to a plane build by their neighbourhood points. This means that the resulting reconstructed surface has a reduced degree of details: it gives no further information about the original object's shape within the given tolerance of 0.01 mm. The mesh gained from this process has a point density

[6] http://www.ogi.at
[7] https://www.volumegraphics.com

of 218 points in average on 1 mm² of the object surface, consisting of 13.408.753 vertices and 26.674.008 faces. On the outer surface of the ceramic body (the matrix) the point density is lower, in average 186 points per 1 mm², whereas the surfaces of the inner pores or air voids have a higher point density due to their stronger curvatures, in average 344 points per 1 mm². The reduced mesh preserves the features as the fine incisions of the black figure technique (Fig. 2c).

To capture the geometry of the incisions of this black-figure aryballos having a wide of 0.2 to 0.4 mm, a spatial resolution of at least 1/2 of the wide is required [Mara 2012; Dahl et al. 2018]. But to represent these features with uneven, irregular edges sufficiently precise, a resolution of 0.05 to 0.1 mm or lower is needed. As known, the resolution is not the only factor determining the quality of a 3D mesh [Moitinho de Almeida et al. 2017; Moitinho de Almeida and Rieke-Zapp 2017]. To capture the fine incisions sufficiently, one needs also a high accuracy which should be considerably lower than the spatial resolution. The knowledge of such accuracy is essential, but normally difficult to gather [Dahl et al. 2018]. As mentioned above, the high accuracy is one of the strengths of CT. Current methods representing the state-of-the-art for segmenting CT volume data allow to reach about 1/10 of a voxel in terms of measurement uncertainty [Karl et al. 2013; De Oliveira et al. 2016]. In this case, it means 5.5 µm.

Fig. 3. The fusion of SfM texture and the CT data in the case of the aryballos KFU Graz G 26

Texturing CT

In addition to the CT model, a Nikon D3X (full frame camera, 24.4 megapixels) – and an electric turntable – was used to create 126 images as input for SfM. The images were processed in the commercial software Agisoft PhotoScan 1.4.3 Standard[8] to create a model with a high-resolution texture map (9999 x 9999 pixels). In MeshLab[9], the roughly scaled SfM model was scaled and aligned to fit the CT model with its absolute measurement. Then the texture of the SfM model was transferred to the closest vertices of the CT model. Of course, only the visible outer surface of the aryballos was captured with SfM, so only the outer surface of the CT model was coloured (Fig. 3).

Although the overall geometry of the scaled SfM model computed with high and very high settings fitted the CT model very well, fine details were missing or roughly visible in the mesh. Looking closer on a small surface section of this aryballos, the high accuracy of CT technology towards SfM is evident (Fig. 4).

[8] since Version 1.5 Agisoft Metashape
[9] http://www.meshlab.net

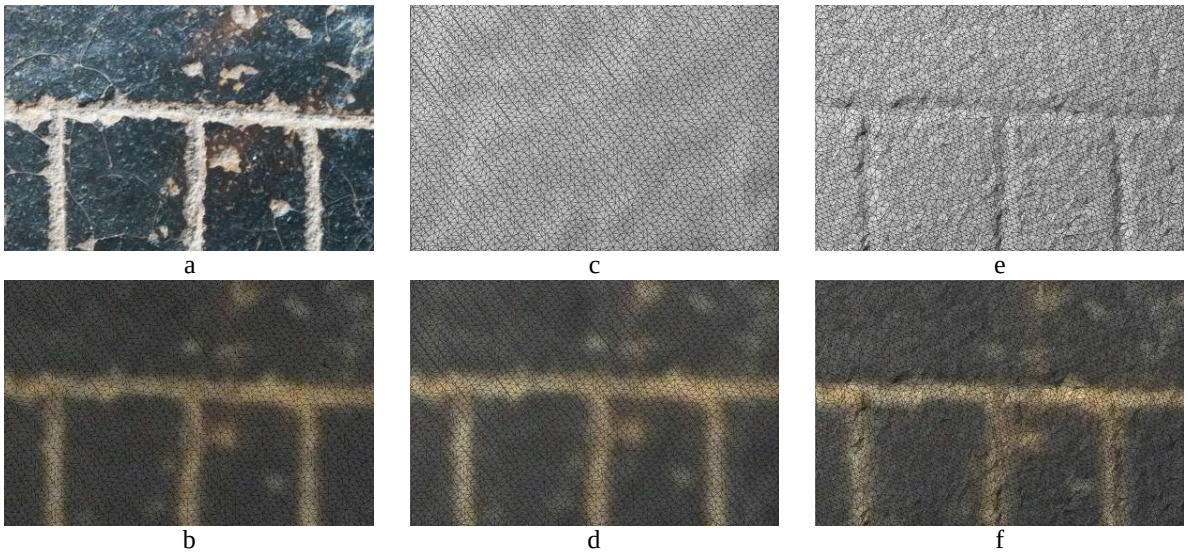


Fig. 4. Section of the aryballos KFU Graz G 26, size 4 x 6 mm: a) photograph; b) SfM mesh with 3949 vertices, in average 164 vertices/mm² (in this section); c) SfM mesh without texture; d) texture transferred to SfM vertices; e) CT surface with 4950 vertices, in average 202 vertices/mm²; f) texture transferred to the CT vertices

Rollouts and Feature enhancement

The fused dataset was processed with the GigaMesh Software Framework, which was used to unroll the body of the aryballos. The latter can be approximated by a sphere, which is defined by four points selected from the surface. The axis of rotation is defined by the orifice plane. Selecting the sphere and the orifice plane requires a minimum of user interaction of a few seconds. As any rollout leads to cutting the surface, an intersecting half-plane was chosen, defined by the axis and a point of low importance to the depiction of the motif.

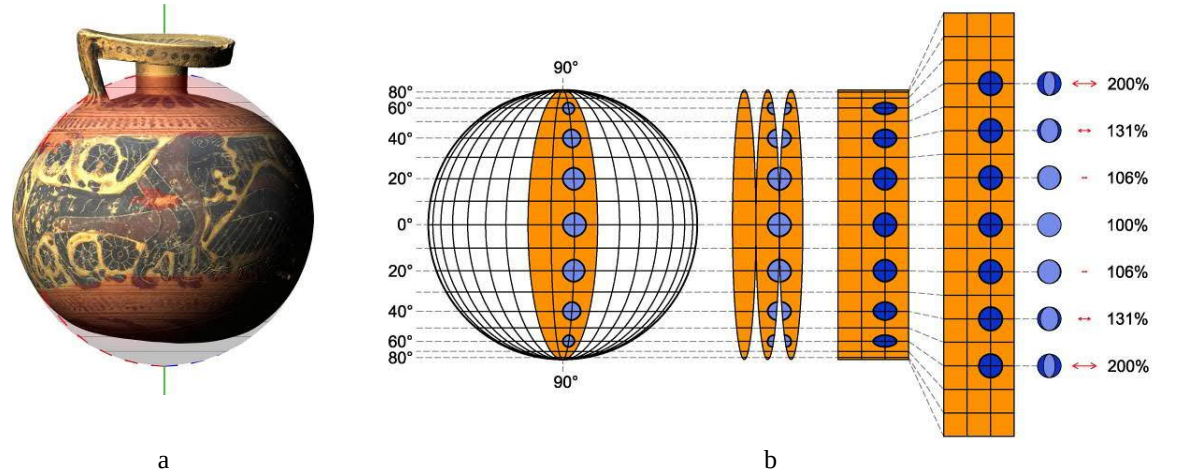


Fig. 5. The used equirectangular projection of a sphere for unwrapping: a) setting in GigaMesh; b) showing the increasing distortions to the poles only along the latitudes

The equirectangular projection is shown in Figure 5 and has proven most suitable for painted pottery among the rollouts using cones and cylinders as well as their combinations [Bechtold et al. 2010; Rieck et al. 2013]. It has no distortions along the longitudinal lines. As the sphere is a non-developable surface, the factor of the distortions along the latitudes can be computed by

$$s_{lat}(\theta) = \frac{1}{\cos(\theta)}$$

whereby θ is the angle formed by the normal at this point to the equatorial plane, similar as in geography.

These rollouts of 3D models are actually an umbrella transformation which deforms the 3D space using the coordinate system of the selected primitive [Apostol and Mnatsakanian 2012]. Such cone-based rollout unfolds like an umbrella which also has to be cut to become flat. The rollout of spheres follows the same principle. This allows the rendering of images with and without texture maps as well as high-contrast renderings based on the MSII filter result highlighting faint and small details. As the umbrella transformation is global, it strongly tends to preserve local i.e. small details like the fine incisions of the Corinthian black-figure pottery. The computation of the Multi-Scale Integral Invariant (MSII) filter of GigaMesh [Mara et al. 2010] was done before unrolling to avoid unwanted artefacts from the deformations of the spherical rollout within the final image. Figure 6 shows from top to bottom the aryballoi after the umbrella transformation with and without texture map. The latter demonstrates that the result of the transformation is still a 3D model, because a shading using virtual light source could be applied. The bottom rendering shows the pre-calculated MSII filter response highlighting the incision.

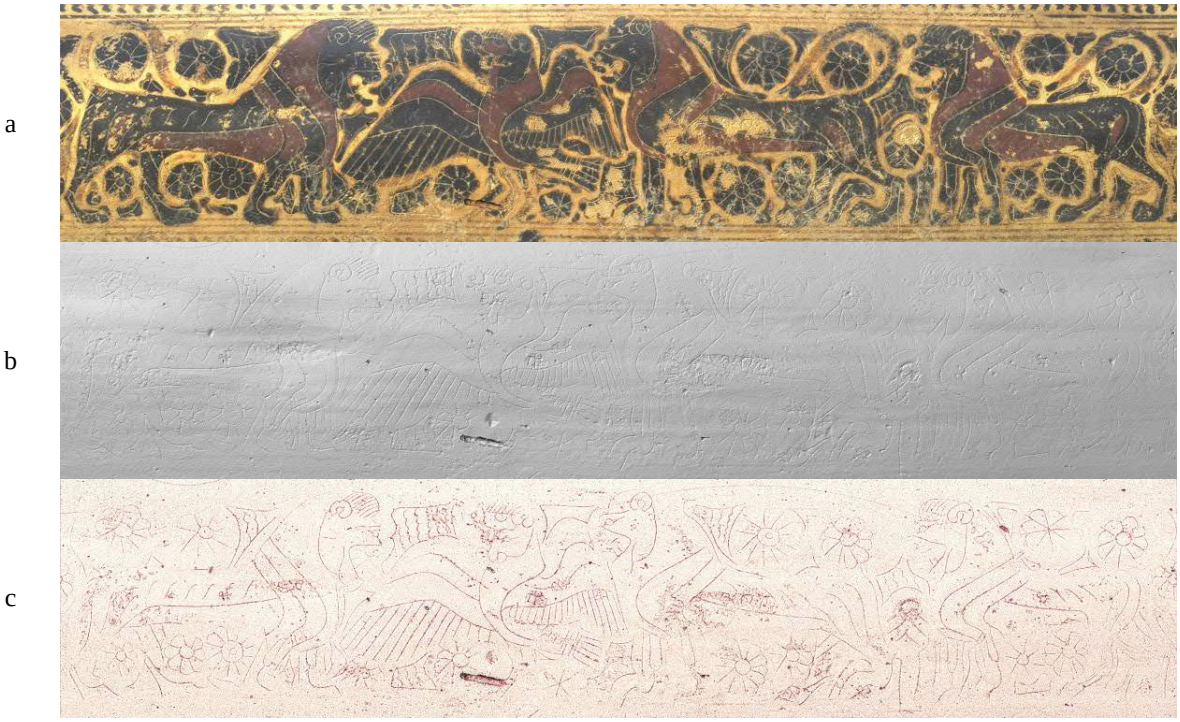


Fig. 6. Rollouts of the painted and incised surface of the aryballos KFU Graz G 26; a) texture; b) surface with shading; c) surface with MSII filtering

Archaeological Drawing

The unrolled MSII filtering and texture layers were used for a detailed graphical annotation aligned to the demands in Corinthian pottery research. This archaeological interpretation task is important in two aspects: (i) distinguishing the incisions of the black-figure painting from other features like scratches or fractures; (ii) recognising the contours of the black glazed and added red areas, also if only traces of flaked off painting layers are left. With the words of Michael Shanks, one has to "distinguish signal from noise" [Shanks 2012]. The drawing was executed and finished as “Scalable Vector Graphic” (SVG) using Inkscape[10] in front of the physical object to verify each line, together with a magnifying glass (Fig. 7). Additionally, the polylines and polygons were separated in different layers relating to incisions of ornaments or figures, contours of ornaments or figures, added red and dividing lines between figures

[10] https://inkscape.org

and ornaments. The working time for the archaeological drawing of the aryballos, which is able to be published in this execution, was 5 hours in total (in this detailed demonstration of 922 lines with 18.610 nodes) (Fig. 8).

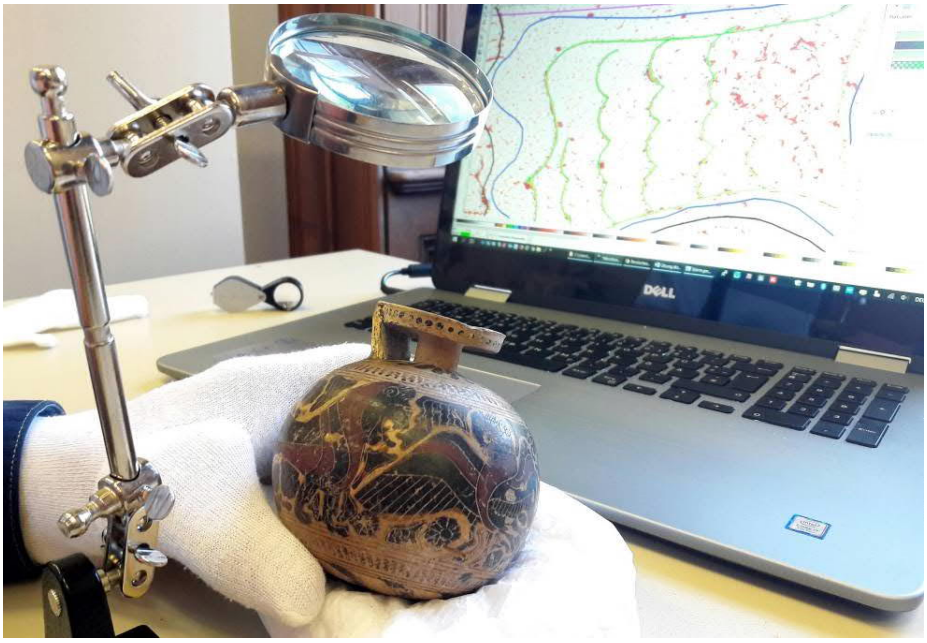


Fig. 7. Archaeological interpretation in front of the original, the aryballos KFU Graz G 26

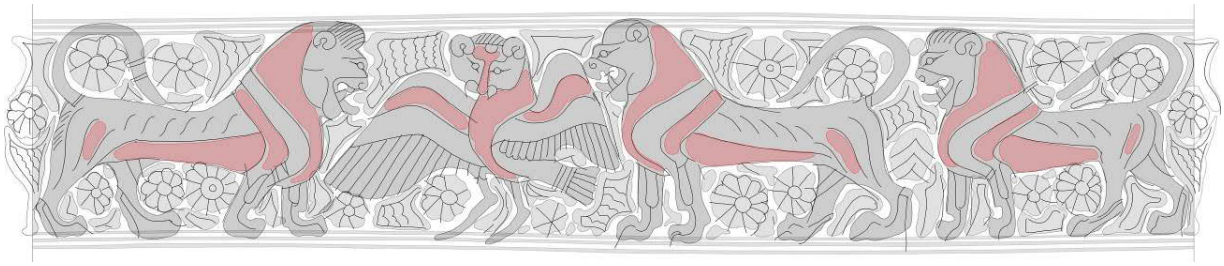


Fig. 8. Archaeological drawing of the black-figure frieze of the aryballos KFU Graz G 26

RESULTS

This non-contact method offers a highly efficient and precise way for executing drawings of Corinthian pottery. Compared to manual drawings, the computed rollout is repeatable by knowing the projection parameters and most important, independent of human skills. The height of the painted frieze on the aryballos ranges between 34° north latitude and 27° south latitude, which means that by using the equirectangular projection the maximal distortion has a scaling factor of 1.21 at the upper border of the frieze, and 1.12 at the lower border. As mentioned in the previous section using this projection method the longitudes are projected in scale 1:1. The occurring distortions are justifiable, the changes within the proportions of the figures and ornaments are neglectable. However, projecting a curved surface to the plane causes mandatorily distortions. In the field of cartography, the challenge of minimising distortions has been tackled since more than two thousand years [Snyder 1993] using different possibilities of unwrappings of the Earth's surface [Van Wijk 2008]. In general, the chosen projection depends on the purpose of the unwrapping. In archaeology, projections with no interrupts are preferred. Relating to Corinthian aryballoi with their painted friezes, which are situated normally within the 40° latitudes (i.e. having a distortion of 131 % at the furthest away latitudes), the equirectangular projection is most suitable. Additionally, using computed rollouts based on 3D models enables to quantify the scaling of the resulting unwrappings.

The projection of a surface of a sphere to a plane is also affected by the topological characteristics of spaces. A sphere in mathematics is a 2D closed surface, i.e. it is without a boundary. Using it for a projection, one has to cut the sphere. This will be done along a meridian in the simplest case. In case of the Greek vase shape, the aryballos, it is appropriate to cut the surface on the vase's backside along a meridian. With densely painted surfaces as on the example KFU Graz G 26, it separates ornaments arbitrarily. To solve this visual constraint, the affected ornaments were manually duplicated on both sides.

Due to the more or less well-preserved surface of archaeological pottery objects, a drawing aligned to pottery standards is mandatory. Despite all developments in computational sciences, this step is performed manually most effective, especially in regard to objects of Corinthian pottery with their typically worn-off surfaces. Anyway, based on the textured and feature enhanced computed rollouts, such drawings are easy and fast to create with basic knowledge in graphic editors. Within this procedure, the separating of all lines in different content layers helps to extract very quickly specific details (Fig. 9). This can be used for rendering details in a painter's oeuvre and its periodisation [Neeft 1998].

However, detecting the incisions and contours in the black-figure painting appropriately, requires a minimum resolution in CT and photogrammetry depending on the fineness of the painting. For the Corinthian black-figure painting a spatial resolution of 0.05–0.1 mm or lower based on an adequate accuracy are recommended.

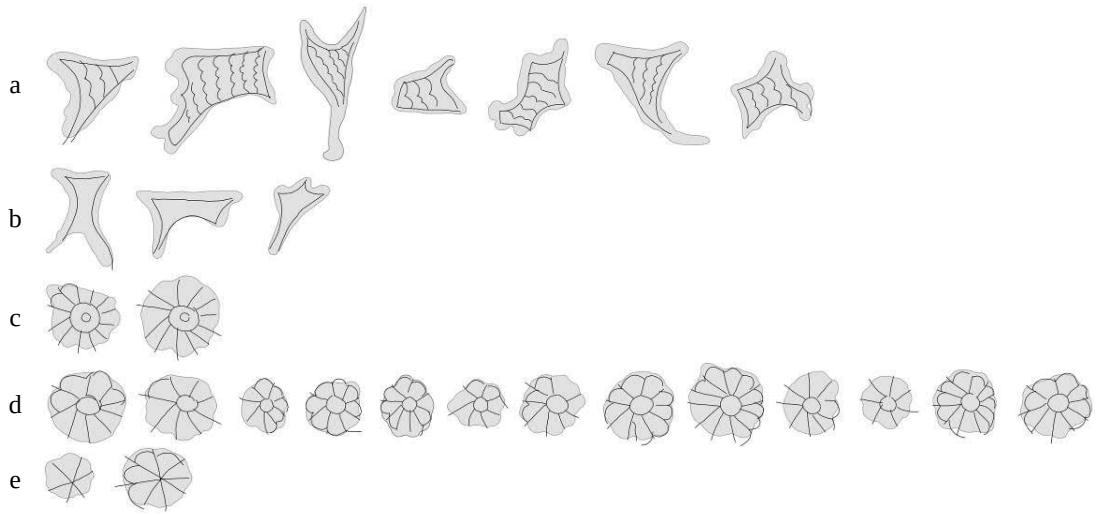


Fig. 9. Selection of specific filling ornaments on the aryballos KFU Graz G 26: a–b) amorphous fillers within an incised frame and with and without wavy incisions formed by interconnected separately drawn arches; c–e) rosettes with and without central heart and petals closed not entirely consistently by semi-circular incisions

This new accurate unwrapping of the aryballos KFU Graz G 26 allows us a fine analysis of the decoration and its style and recognise the painter's hand on another vase: Paris, Louvre, inv. Cp 12420, reconstructed from the so-called Campana fragments coming possibly from Cerveteri (Fig. 10). The decoration of the mouth-plate and the bottom repeats the syntax of the Warrior Group [Amyx 1988]. The extra decorative band above and below the main decoration of the body is rare, but not unheard on the vases of the Warrior Group, see in particularly the vases of the Sydney Cluster and the Equine Constellation [Amyx 1988]. However, the vase's size is bigger than the aryballoi of the Warrior Group and its style is different to the live and neat, sometimes archaistic decoration of the Warrior Group. The painter uses particular decorative motifs, such as the amorphous filling ornament divided by wavy incisions formed by interconnected separately drawn arches within an incised frame (Fig. 9a) and the rosettes with incised central heart and radiating incisions forming the petals that are closed not entirely consistently by a semi-circular incision (Fig. 9c–d). The filling ornaments of the bands framing the frieze, like the reversed Zs and the undulated diagonal lines, appear on aryballoi and alabastra dating from the later part of the Early Corinthian and the first half of the Middle Corinthian, meanwhile the row of double dots continued at least to the end of the Middle Corinthian. The panther and the lion show an advanced version of the Early Corinthian type with some touches announcing the Middle Corinthian style. The framed amorphous filling ornaments appeared on alabastra and aryballoi in the advanced stage of the Early Corinthian and remained in use in the Middle Corinthian [Lawrence

1998]. The Graz aryballos thus can be dated to the Late Early, or to the Transition from Early to Middle Corinthian. The Louvre vase is a little bit coarser and less careful work comparing to the aryballos in Graz. The filling ornaments are simpler and the large sized amorphous filling ornaments with this special kind of wavy incisions (Fig. 9a) seem to be omitted. It may point a later date in the painter's career and may be tentatively dated to the Transition from Early to Middle Corinthian, or the beginning of the Middle Corinthian period. In absolute dates, the painter activity can be symbolically situated between 600/590–585 BC.

a b c d

Fig. 10. A comparison of the lion on the aryballos Louvre Cp 12420, © musée du Louvre / András Márton (a–b) and KFU Graz G 26 (c–d), showing the characteristics of the painter's hand

CONCLUSION

One of the main objectives of the first edition of a vase or a reference publication, such as the *Corpus Vasorum Antiquorum*, is to provide a high-quality visual documentation for everybody who needs to work with the vase. Computed rollouts coupled with an accurate and sufficiently detailed archaeological drawing provide a sound basis for the stylistic analysis of painters and workshops. Only a meticulous fine documentation can reveal the particularities and characteristics of a painter and can help to recognise these on other vessels.

Constraints from the museum regarding CT – mainly because the object has to go to the CT laboratory and not vice versa – "Structured Light Scanning" (SLS) is an adequate alternative for capturing high-resolution models, at least of the visible surface. Of course, the usage of appropriate small measuring fields is necessary to achieve the required resolution in geometric data for detecting the incisions.

The minimisation of distortions for rollouts of high-resolution 3D-measurement data is an interesting challenge for algorithm development in the domain intersection of human perception and computer vision. Rollouts with visual correspondences showing longitudes and latitudes or visualisations of the scale of the incurred distortions, e.g. as stress map will improve the scientific documentation. Regarding the question for a proper segmentation, how do cut a sphere without dividing ornaments or – worse – figures, is an additional challenge in computer graphics.

Of course, the peculiar added value of CT is its ability to look into a closed vessel or into the material ceramic itself. This allows the computing of profile sections as well as visualisations and rollouts of the inner surface, as shown in an accompanying video[11]. Additionally, pores and inclusions in the ceramic fabric can be analysed according to amount, size, shape and orientation. CT shows and unveils significant details of the manufacturing process and of the fabric.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Univ.-Prof. Dr. Peter Scherrer, Head of the Institute of Archaeology and Vice-

[11] DOI: 10.11588/heidok.00025189; http://www.ub.uni-heidelberg.de/archiv/25189

Rector for Research and Junior Researchers' Promotion at KFU Graz, for the financial support of this work, and Dr. Anne Coulié, Conservateur en chef, AGER, musée du Louvre, for her kind permission to illustrate the Louvre aryballos. A special thank goes to Dr. Johanna Kraschitzer, member of the Institute of Archaeology at Graz, for the close-up photographs of the aryballos KFU Graz G 26.

REFERENCES

Darrell A. Amyx. 1988. *Corinthian Vase-Painting of the Archaic Period*. Berkeley, Los Angeles, London: University of California Press.

Tom M. Apostol and Mamikon A. Mnatsakanian, 2012. New Horizons in Geometry., Washington: Dolciani Mathematical Expositions, Mathematical Association of America.

Aleese Barron and Tim Denham. 2018. A microCT protocol for the visualisation and identification of domesticated plant remains within pottery sherds. *Journal of Archaeological Science: Reports* 21 (2018), 350–358.

Sebastian Bechtold, Susanne Krömker, Hubert Mara, and Bettina Kratzmüller. 2010. Rollouts of Fine Ware Pottery using High Resolution 3D Meshes. In Alessandro Artusi, Morwena Joly-Parvex, Genevieve Lucet, Alejandro Ribes, and Denis Pitzalis, eds. *Proceedings of the 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST)*. Eurographics Association, 79–86.

Andrea Buratti, Judith Bredemann, Michele Pavan, Robert Schmitt, and Simone Carmignato. 2017. Applications of CT for Dimensional Metrology. In Simone Carmignato, Wim Dewulf, and Richard Leach, eds. *Industrial X-Ray computed tomography*. Cham: Springer International Publishing, 333–369.

Maria Christidis, Stephan Karl, Gabriele Koiner and Gerda Schwarz. 2014. *Corpus Vasorum Antiquorum, Österreich 6, Graz, Originalsammlung des Instituts für Archäologie der Karl-Franzens-Universität 1*. Vienna: Verlag der ÖAW.

Jacob L. Dahl, Jonathon S. Hare, Kate Kelley, Kirk Martinez, and David Young. 2018. A structured light approach to imaging ancient Near Eastern cylinder seals: how efficient 3D imaging may facilitate corpuswide research. In Kate Kelley and Rachel K. L. Wood, eds. *Digital Imaging of Artefacts: Developments in Methods and Aims*., Oxford: Archaeopress, 49–74.

Fabrício De Oliveira, Alessandro Stolfi, Markus Bartscher, Leonardo De Chiffre, and Ulrich Neuschaefer-Rube. 2016. Experimental investigation of surface determination process on multi-material components for dimensional computed tomography. *Case Studies in Nondestructive Testing and Evaluation* 6 (2016), 93–103.

Lindsley F. Hall. 1936. Notes on the drawings. In Gisela M.A. Richter, *Red-figured Athenian Vases in the Metropolitan Museum of Art*. New Haven: Yale University Press, vii–x.

Christian Hörr. 2011. *Algorithmen zur automatisierten Dokumentation und Klassifikation archäologischer Gefäße*. Dissertation. Chemnitz University of Technology. http://nbn-resolving.de/urn:nbn:de:bsz:ch1-qucosa-71895

Christian Hörr, Elisabeth Lindinger, and Guido Brunnett. 2011. Considerations on Technical Sketch Generation from 3D Scanned Cultural Heritage. In Erzsébet Jerem, Ferenc Redő, and Vajk Szeverényi, eds. *On the Road to Reconstructing the Past. Computer Applications and Quantitative Methods in Archaeology (CAA). Proceedings of the 36th International Conference. Budapest, April 2-6, 2008*. Budapest: Archaeolingua, 258–267.

Daniel Jungblut. 2012. *Rekonstruktion von Oberflächenmorphologien und Merkmalskeletten aus dreidimensionalen Daten unter Verwendung hochparalleler Rechnerarchitekturen*. Dissertation. University of Frankfurt. http://publikationen.ub.uni-frankfurt.de/frontdoor/index/index/docId/27795

Daniel Jungblut, Stephan Karl, Hubert Mara, Susanne Krömker, and Gabriel Wittum. 2013. Automated GPU-Based Sur-face Morphology Reconstruction of Volume Data for Archaeology. In Hans G. Bock, Willi Jäger, and Michael J. Winckler, eds. *Scientific Computing and Cultural Heritage, Contributions in Computional Humanities*. Heidelberg: Springer, 41–49.

Wolf-Achim Kahl and Britta Ramminger. 2012. Non-destructive fabric analysis of prehistoric pottery using high-resolution X-ray microtomography: a pilot study on the late Mesolithic to Neolithic site Hamburg-Boberg. *Journal of Archaeological Science 39*, 2206–2219.

Stephan Karl, Daniel Jungblut, and Jördis Rosc. 2013. Berührungsfreie und nicht invasive Untersuchung antiker Keramik mittels industrieller Röntgen-Computertomografie. In Elisabeth Trinkl, ed. *Interdisziplinäre Dokumentations- und Visualisierungsmethoden*. Vienna: CVA Österreich Beih. 1, Verlag der ÖAW, 73–114.

Stephan Karl, Kamil S. Kazimierski, and Christoph Hauzenberger. 2018. An interdisciplinary approach to studying archaeological vase paintings using computed tomography combined with mineralogical and geochemical methods. A Corinthian alabastron by the Erlenmeyer Painter revisited. *Journal of Cultural Heritage* 31 (2018), 63–71.

Jannis Kozatsas, Kostas Kotsakis, Dimitrios Sagris, and Konstantinos David. 2018. Inside out: Assessing pottery forming techniques with micro-CT scanning. An example from Middle Neolithic Thessaly. *Journal of Archaeological Science* 100 (2018), 102–119.

Patricia Lawrence. 1998. The Luxus Phenomenon I. The Taucheira Painter and Closely Related Hands. *Hesperia* 67 (1998), 303–322.

Hubert Mara. 2012. *Multi-Scale Integral Invariants for Robust Character Extraction from Irregular Polygon Mesh Data*. Dissertation, University of Heidelberg. https://archiv.ub.uni-heidelberg.de/volltextserver/13890

Hubert Mara and Julia Portl. 2013. Acquisition and Documentation of Vessels using High-Resolution 3D-Scanners. In Elisabeth Trinkl, ed. *Interdisziplinäre Dokumentations- und Visualisierungsmethoden*. Vienna: CVA Österreich Beih. 1, Verlag der ÖAW, 25–40.

Hubert Mara, Susanne Krömker, Stefan Jakob, and Bernd Breuckmann, 2010. GigaMesh and Gilgamesh – 3D Multiscale Integral Invariant Cuneiform Character Extraction. In Alessandro Artusi, Morwena Joly, Genevieve Lucet, Denis Pitzalis, and Alejandro Ribes, eds. *Proceedings of the 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST), Paris, 21–24 Sept. 2010*. Eurographics Association, 131–138.

Vera Moitinho de Almeida, Stefanie Wefers, and Orla Murphy. 2017. An Interdisciplinary Discussion of the Terminologies used in Cultural Heritage Research. In Anna Bentkowska-Kafel and Lindsay MacDonald, eds. *Digital Techniques for Documenting and Preserving Cultural Heritage*. Kalamazoo, Bradford: ARC Humanities Press, 3–16.

Vera Moitinho de Almeida and Dirk Rieke-Zapp. 2017. Generación de datos 3D con sistemas ópticos de medición de corto alcance. In Diego Jiménez-Badillo, ed. *Arqueología computacional. Nuevos enfoques para la documentación, análisis y difusión del patrimonio cultural*. México: Instituto Nacional de Antropología e Historia, 93–109.

Cornelis W. Neeft. 1998. Who Precisely Was the Fledgling Painter. In Renate Rolle, Karin Schmidt, and Roald F. Docter, eds. *Archäologische Studien in Kontaktzonen der antiken Welt. Festschrift Hans-Georg Niemeyer*. Göttingen: Veröffentlichungen der Joachim Jungius-Gesellschaft der Wissenschaften 87, Vandenhoeck & Ruprecht, 265–285.

Cornelis W. Neeft. 2013. The KP 64 Workshop at Taranto. In Giuseppe Andreassi, Assunta Cocchiaro, and Antonietta Dell'Aglio, eds. *Vetustis novitatem dare. Temi di antichità e archeologia in ricordo di Grazia Angela Maruggi*. Mottola: Scorpione Editrice, 559–568.

Kees Neeft. 2017. The Sphinx Painter and his Workshop. In Vicky Vlachou and Anastasia Gadolou, eds. *ΤΕΡΨΙΣ. Studies in Mediterranean Archaeology in honour of Nota Kourou*. Bruxelles: Études d'archéologie 10, Le Livre Timperman, 75–89.

Erica Nocerino, Dirk H. Rieke-Zapp, Elisabeth Trinkl, Ralph Rosenbauer, Elisabetta M. Farella, Daniele Morabito, and Fabio Remondino. 2018. Mapping VIS and UVL imagery on 3D geometry for non-invasive, non-contact analysis of a vase. *ISPRS Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLII-2 (2018), 773–780. DOI https://doi.org/10.5194/isprs-archives-XLII-2-773-2018

Ruggero Pintus, Kazim Pal, Ying Yang, Tim Weyrich, Enrico Gobbetti, and Holly Rushmeier. 2016. A Survey of Geometric Analysis in Cultural Heritage. *Computer Graphics Forum* 35 (2016), 4–31.

Denis Pitzalis, Paolo Cignoni, Michel Menu, and Genevieve Aitken. 2008. 3D enhanced model from multiple data sources for the analysis of the Cylinder seal of Ibni-Sharrum. In Michael Ashley, Sorin Hermon, Alberto Proenca, and Karina Rodriguez-Echavarri, eds. *Proceedings of the 9th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST)*. Eurographics Association, 79–84.

Bastian Rieck, Hubert Mara, and Susanne Krömker. 2013. Unwrapping Highly-Detailed 3D Meshes of Rotationally Symmetric Man-Made Objects. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences II-5/W1* (2013), 259–264. DOI https://doi.org/10.5194/isprsannals-II-5-W1-259-2013

Matthew C. Sanger. 2016. Investigating pottery vessels manufacturing techniques using radiographic imaging and computed tomography: Studies from the Late Archaic American Southeast. *Journal of Archaeological Science: Reports* 9 (2016), 586–598.

Michael Shanks. 2012. *The Archaeological Imagination*. Walnut Creek: Left Coast Press.

John P. Snyder. 1993. *Flattening the Earth: Two Thousand Years of Map Projections*. Chicago: University of Chicago Press.

Andrew Townsend, Luca Pagani, Paul Scott, and Liam Blunt. 2017. Areal surface texture data extraction from X-ray computed tomography reconstructions of metal additively manufactured parts. *Precision Engineering* 48 (2017), 254–264.

François Villard. 1965. *Corpus Vasorum Antiquorum, France 21, Musée du Louvre 13*. Paris: H. Champion.

Christine Walter. 2008. Towards a More 'Scientific' Archaeological Tool. The Accurate Drawing of Greek Vases Between the End of the Nineteenth and the First Half of the Twentieth Centuries. In Nathan Schlanger and Jarl Nordbladh, eds. *Archives, Ancestors, Practices: Archaeology in the Light of its History*. New York: Berghahn Books, 179–190.

Jarke J. van Wijk. 2008. Unfolding the Earth: Myriahedral Projections. *The Cartographic Journal* 45 (2008), 32–42.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz
The editor's office is not responsible for the linguistic correctness of the manuscripts.
Authors are responsible for the contents and copyrights of the illustrations/photographs.

3D Digitization of the Brussels City Hall and the Medieval Archangel Michael Wind Vane: Architectural and Archaeological Exploitation

ARNAUD SCHENKEL, RUDY ERCEK, and OLIVIER DEBEIR, Laboratory of Image: Synthesis and Analysis, Université Libre de Bruxelles, Belgium

In order to make the architectural and archaeological study, the roofs, the courtyard and the facades of the Brussels City Hall were digitized with a 3D scanner, coupled with photographic acquisitions. Various elements, such as the main portal tympanum and the archangel Michael – an exceptionally preserved 5-metre-high medieval metal wind vane that adorned the top of the 96-metre-high tower – were also digitized in high definition. Numerical surveys show different colorimetric (variation of colorimetry related to the changes in natural lighting) and geometric defects (erroneous points related to the passages of persons and vehicles, flying points or noises inherent to the acquisition device). A specific and automatic processing pipeline has therefore been developed and applied to correct all these problems. Given the amount of data and operations for creating plans, a software has been developed to present the data as an enriched 2D representation. This is similar to orthophotos complemented by the possibility to navigate in the depth and to vary the rendering mode (color, intensity, orientation ...), to highlight elements (surfaces, edges ...) hardly visible in simple color mode of rendering. Its functionalities allowed the realization of very precise elevations and to generate projection images in high definition of all buildings parts and also of the archangel statue. Indeed, this survey allowed drawing the entire statue to the real scale and in a completely proportioned way. Archeologists have been able to distinguish the main work components, and they better understand the articulations between its constitutive parts and the various transformations made to the metal statue over the centuries.

Key words:
3D scanning, automatic pipeline, archaeological exploitation, multimodal rendering.

CHNT Reference:
Arnaud Schenkel et al. 2018. 3D Digitization of the Brussels City Hall and the Medieval Archangel Michael Wind Vane: Architectural and Archaeological Exploitation.

INTRODUCTION

For many old buildings, such as the Brussels City Hall, there are no more architectural plans reflecting their current state. It is therefore necessary to carry out a measurement survey in order to obtain precise plans of roofs, facades and room configuration, for different purposes like the architectural studies, some major renovations, or the monitoring of its evolution.

In many cases, facade survey missions ordered to professionals are carried out at a predefined resolution; it is impossible to obtain measures that would not have been planned at the beginning of the project. One of the goals of our project is to develop a complete solution to extract the necessary measurements from 3D acquisitions, in formats compatible with standard software used in the architectural field, and to be able to supplement them later with information about details, according to new needs. The tool developed must also consider the very large volume of data to be processed, while ensuring easy and fluid handling for non-specialized users.

About the medieval archangel Michael wind vane, the archeological goal of the project is to obtain a three-dimensional model faithful to reality, usable to evaluate archaeological hypotheses: renderings of the original aspect of the materials, variations of armaments (e.g. a spear instead of the sword).

The position in the center of Brussels and the accessibility of the building limited the type of usable acquisition device to long range scanner to cover a maximum of the surface. Likewise, the size of the wind vane limits the

usable digitalization processes. Indeed, terrestrial and aerial photogrammetry require accessibilities and access rights limiting their practical use in the field.

Brussels City Hall and Medieval Wind Vane Acquisitions

The Brussels City Hall, as it can currently be seen, is the result of different phases of construction, described in Fig. 1, followed by restorations. The first part dates from the 15th century. It was built in Gothic style and extended to keep a harmonious style. The entire building was completed in 1455, by raising the tower and placing the statue-vane of Archangel Michael at its summit. The City Hall was restored a first time after the bombardment of Brussels in 1695 by the French army. The second wing was built then, lower than the rest of the building and arranged in a U-shape, delimiting a courtyard.

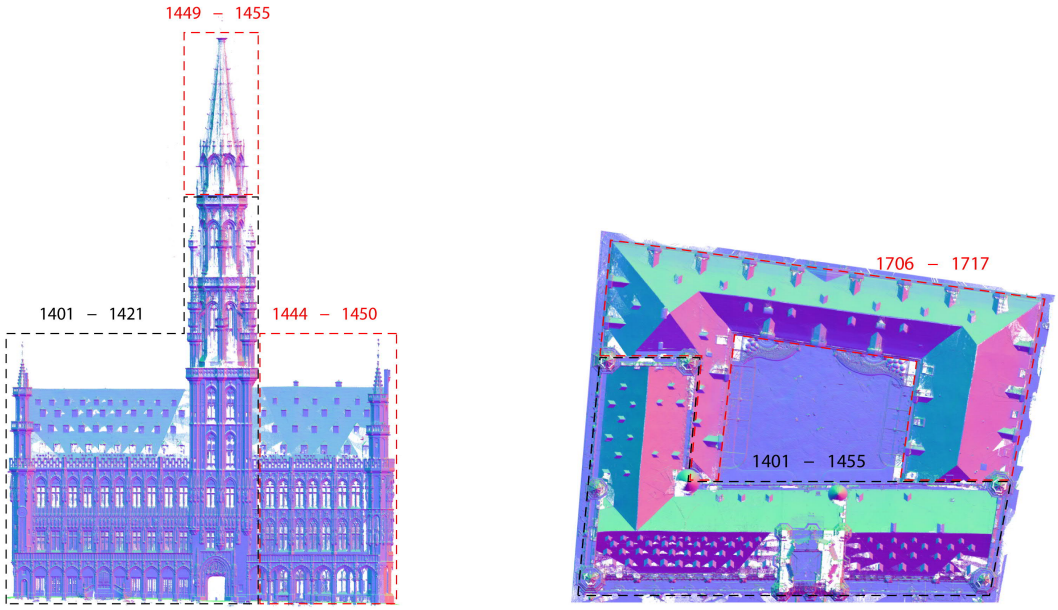


Fig. 1. Construction steps of the Brussels City Hall. a) View of the front façade and b) aerial view. The models correspond to the data acquired and are colorized according to the normal of the points. For rendering, each component of the vector obtained is normalized and represented by a different color channel

During the 19th century, the facades underwent various restoration campaigns (including the replacement of the original sculptures by copies), as well as embellishment campaigns. Thus, 294 new statues, personalizing former Brabant rulers and their families, important magistrates of the City and personalities from fine arts, gradually come to fill the numerous niches remained empty since their construction.

In 2015, two survey campaigns made possible to obtain all facades and roofs of the Brussels City Hall as a big point cloud (see Fig. 2). A FARO S120 3D Scanner was used in order to acquire all points in high definition with a 0.035° step angle for global acquisitions and a 0.0175° step angle for details. The second configuration is defined to have some parts in higher resolution for algorithm testing. No targets were used in the acquisition because the point density was high enough to register scans by only using geometry.

Fig. 2. Point cloud of the Brussels City Hall acquired with a Faro S120 3D Scanner

The acquisition of the building presents some difficulties inherent to its position in the historic center of Brussels:

- Placement limitations, inducing the presence of geometrical shadows in the model and a resolution limitation: the front facade is far from the nearest building and conversely the side facades are close to the neighboring buildings, which imply the impossibility to have some direct front views or elevated views. The balcony at the base of the roof is obstructed, limiting access to some interesting views (for example, the roof areas at the base of the tower);
- Range limitation: the tower is very high (nearly 100 m) and was not the main object of interest of our study, so it is difficult to obtain a high resolution of this part, without allocating a lot of resources (staff, equipment, time …), and the same problem applies to the statues of the facades;
- Limitation due to pedestrian traffic: many acquisitions have been made from ground areas (from the square, the surrounding streets and the inner courtyard) which cannot be closed for tourists.

In total, 97 scans positions were necessary to obtain the external building. However, due to the building complexity and the difficulty to have good viewpoints with valid ranges and good incidence angles, some geometries have not been correctly acquired. Moreover, some details were acquired in very high definition (see Fig. 3), such as the main portal tympanum, the lion statue located in the gallery of the left wing, or a column in the gallery of the right wing.

a *b*

Fig. 3. High resolution 3D scans of details of the Brussels City Hall: a) main portal tympanum, b) the medieval archangel Michael wind vane with the positions of the scanner acquisitions

The medieval archangel Michael wind vane, patron saint of Brussels, was installed in 1455 at about 97 m height, on the point of the belfry of the City Hall. In 1993, the original version of Martin Van Rode, too altered to be restored a second time, was sheltered in an inner room of the tower and replaced by a copy. The entire statue, from the base to the tip of the sword, is nearly 5 m high. The digitalization of the medieval archangel Michael wind vane took 13 scan positions in order to obtain a high-resolution model of this statue (see Fig. 3(b)) in natural light conditions with the FARO 3D. But, considering the height of the object and the absence of a plunging point of view, the upper part could not be scanned.

In addition to the geometry acquisition, pictures were taken by the scanner in order to colorize the point cloud. In order to do that, the FARO 3D scanner is equipped with an integrated camera located near the optical center of the device that allows associating color information for each 3D point. Table 1 gives a summary of all acquired data, where the valid points only correspond to the ones inside the object of interest. For example, it is nearly impossible to limit the acquisition to the building facades without acquiring other nearby facades.

Table 1. Information about acquired models

3D Model	Number of scans	Number of 3D points	Number of valid 3D points	Number of pictures
City Hall	97	2.7 Billion	1.8 Billion	5841
Wind vane	13	228.9 Million	228.3 Million	377

DATA PROCESSING

In variable and uncontrolled light conditions, for big complex outside sites, the 3D models acquired with laser scanners and cameras have a lot of geometric (like noise, flying points, outliers, moving objects) and colorimetric (like overexposure, light variation, shadows) defects.

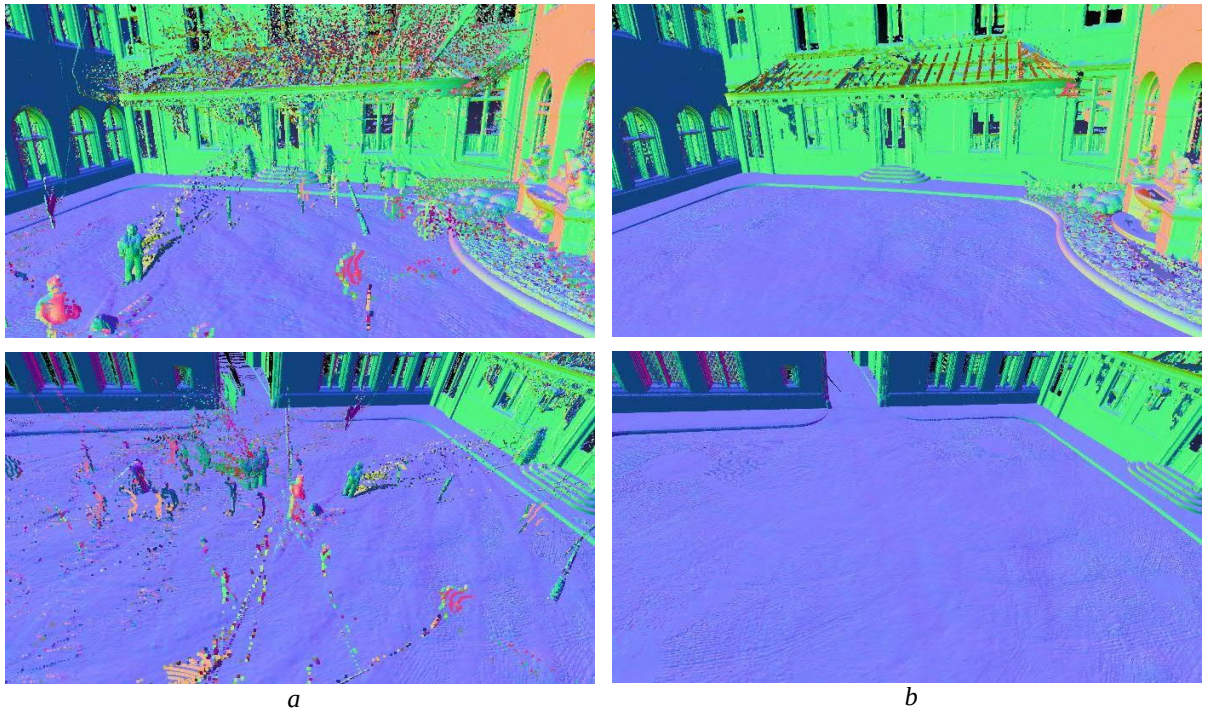
In point clouds, considering the use and the precise alignment of several scans, different forms of artifacts may appear; but it is difficult to associate a precise and unique consequence with each existing source of errors [Schenkel 2017]. Several consequences are frequently observable:

- Measurement noise is generally considered as randomly distributed points near the surface (front or back). In scanner acquisitions, it is introduced along the line of sight according to a specific distribution of the distance-dependent error, which depends on the acquisition tool (sensor noise, quantization error), the methodology (distance and orientation of the scanner with respect to the surface), the environment (attenuation of the signal in the air) and the target (properties of the surface, diffusion characteristic of the materials);
- Outliers occur when ideal conditions are not met and are therefore almost unavoidable artifacts of acquisition systems. From a geometrical point of view, the outlier values in a point cloud are the measurement that are not part of the digitized area and should be removed;
- Flying points appear separately from other points in positions where no surface exists in reality. They occur on the edges of objects where there is a sudden change in depth from one object to another, where the surfaces of the two objects influence the measured depth value so that the obtained value approaches a weighted average of both distances. These artifacts tend to become systematic with the increasing of the angular resolutions and of the measurement distances;
- Inconsistencies in the scene. For building acquisitions, several scans are needed, but can spread widely over time. It is not always possible to ensure a complete closure of the site to visitors or that no equipment or objects are moved during this process. This leads to inconsistencies in the scene or ghost geometries that are captured only in a single or a small number of acquisitions. All objects that are not persistent in the scene can therefore introduce artifacts into a scan that can dramatically compromise the quality of the results.

An automatic pipeline has been developed in order to cope with these problems [Schenkel 2017]. In order to correct these defects, the data processing was based on a point description of the acquisitions since 3D points are obtained as raw data from a laser scanner and also because correct visual renderings can be easily computed from points. Due to the big size of the models, the measures are structured as multi-data layers maps (e.g. ranges, point colors, etc.) for each scan position, allowing to easily load and treat them in the computer memory. This structure corresponds to the original data format, avoiding a multi-scale data transformation (e.g. octree) that would take a lot of time, without any advantage for our application.

The method for detecting flying points in each scan position is based on the distribution of the points with respect to the acquisition center, more precisely by using a threshold on the angle between the normal of the point and the scan viewpoint. The identification of inconsistencies in the point cloud (i.e. moving points) is based on the comparison between all acquisitions of the zone of interest and on common ideas of [Kanzok et al. 2013] and [Zeibak and Filin 2007], without the necessity of data restructuring. A majority vote approach and the comparison of local features taking into account several criteria (position, normal, color, etc.) allows good identification of outliers, while avoiding misidentification and deletion of too many valid points.

Fig. 4 gives two examples of a render in false colors (corresponding to the normal) for the City Hall courtyard before and after cleaning the geometric defects. The presence of the different types of geometric errors can be easily observed: flying points are present above the glass veranda; silhouettes show the presence of visitors during the survey, different objects along the facade (plants, trash cans) were also moved between the acquisitions. All these problems are handled correctly.



a *b*

Fig. 4. Cleaning of geometric errors (flying points, moving points and inconsistencies) for the City Hall courtyard: a) Raw points clouds, b) Points cloud corrected with the proposed method

Without complementary processing, variations of light conditions during acquisitions cause an unpleasant geometric rendering (see Fig. 5a and 5c). In order to cope with this problem, an original colorization method, based on Baumberg [2002], Callieri et al. [2008] and Pintus et al. [2011] research, has been developed. In summary, the point color is obtained by using all available pictures and by weighting them with its respective local quality as explained in [Schenkel and Debeir 2015] and taking into account the intrinsic picture quality (shadows presence, overexposure, etc.) but also the pictures capture conditions (source position and orientation with respect to the geometry, or the model silhouette in relation to the view point). Fig. 5 shows this problem with its corrected result.

a *b*

c d

Fig. 5. Example of color correction for the City Hall Courtyard: a) & c) Raw points cloud, b) & d) Corrected colors model

ARCHITECTURAL EXPLOITATION

Many software solutions exist on the market, but they often have different limitations for the users:

- in 3D view, the data manipulation can cause some confusions: transparency within a point-based model, difficulties to identify neighboring elements, human-computer interactions to correctly orient the view, ...
- the amount of data to be manipulated involves octree-based data restructuring or similar approach, so all points are not directly and necessarily displayed, often imputing repetitive data loading times with each move or manipulations ;
- the point cloud colorizations are limited to some basic information, such as color, height, intensity... while information like the normal to the surface, yet elementary for the geometric extraction, is largely ignored...

The software LisaCAD (see Fig. 6), named from the contraction of the LISA department having developed the solution and computer aided design or CAD, was created specifically to meet the needs of the architects of the City of Brussels, in order to use 3D scans to establish accurate plans of the Brussels City Hall.

In order to do that, the scans are projected in a grid discretizing a projection plane and corresponding to a cut plane, a facade elevation or any other plane of interest. Each grid element has several projected points at different depths (in a selected range, generally 0 to 11 m to the plane) that allow to interact with the point distance to the plane and the angle between the normal of the point and the plane normal, for example in order to display the balconies and what is behind them. So, only the first grid element (point) in the selected depth range and normal angle can be shown as an image pixel.

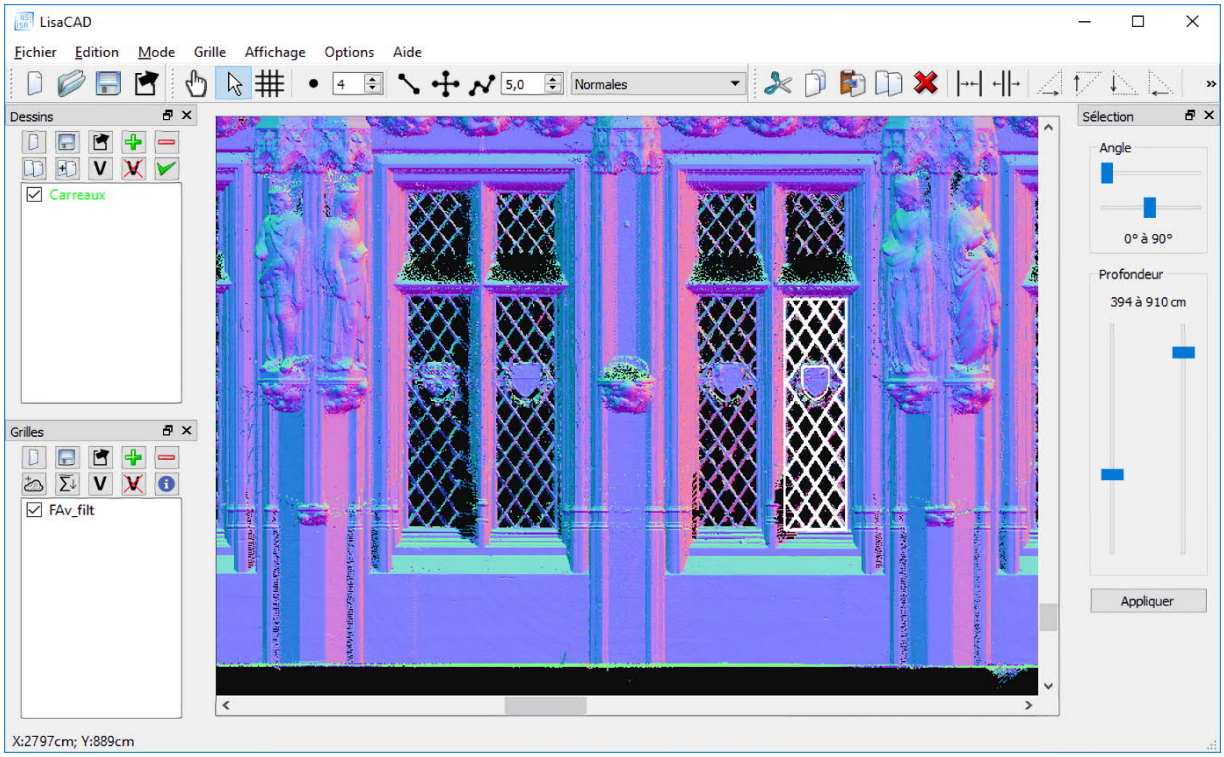


Fig. 6. LisaCAD screenshot with the front facade windows in normal color where a stained-glass window is drawn in white color

Each point contains different interesting information that can be displayed in true or false colors (using a color pallet) depending on the selected display mode e.g. picture color, infrared laser intensity, depth/distance of the point from the plane, point normal, etc. (see Table 2 for all available display modes). The software can export these grids as images displayed in LisaCAD. Fig. 7 shows several examples of images obtained in different display modes for the Brussels City Hall. In this case, a grid element (pixel) represents a resolution of 1 cm².

Table 2. Available grid display modes in the software LisaCAD

Display mode	Description
Color	Point true color taken by the integrated scanner camera.
Intensity	Infrared laser intensity measured by the 3D scanner, in grayscale color. This mode gives some information on the material type (concrete, wood, etc.) and its color, as a black and white picture, but without the influence of external light.
Normal	Each RGB color channel of the grid element corresponds to a component of the point normal, respectively red for the x component, green for the y component and blue for z component. This mode highlights the reliefs.
Absolute normal	Each RGB color channel corresponds to the component absolute value of the point normal. This mode highlights the parallel surfaces to the projection plane in blue color and the perpendicular ones in green color for horizontal and in red for vertical.
Angle	Angle between the point normal and the projection plane normal. This mode highlights the identical surface curvature by its similar color.
Depth	Distance/depth of the displayed point. This mode highlights the nearest point to the projection plane (in blue) with respect to the furthest point to the projection plane (in red).

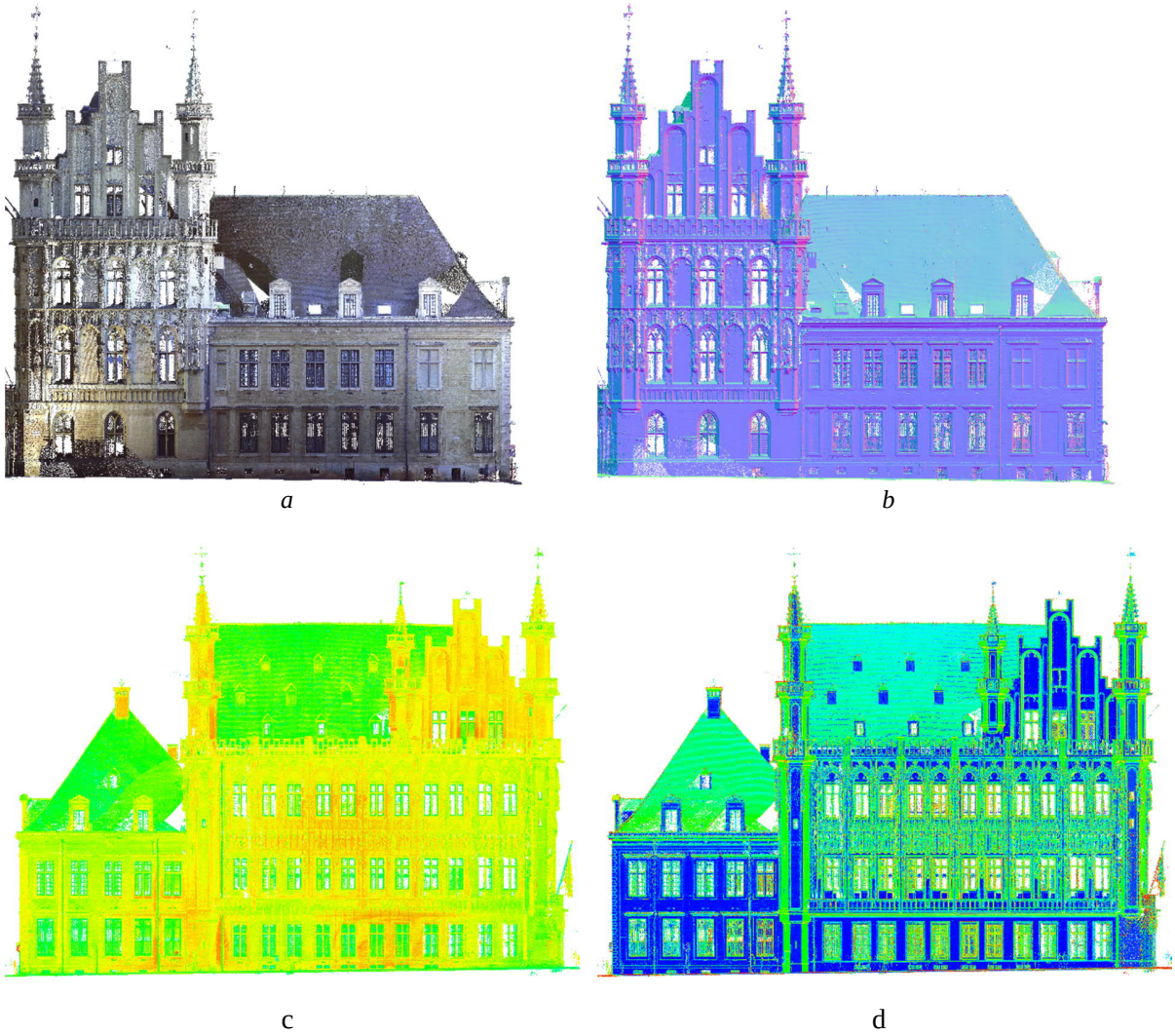


Fig. 7. Facades projections (grids) of the Brussels City Hall in several display modes: a) Right facade elevation (Rue de la Tête d'or) in true color, and b) in normal color. c) Left facade elevation (Rue Charles Buls), and d) in angle color

In the software LisaCAD, grids are used as drawing background in order to create vector plans composed of geometric primitives that can be imported in CAD software such as AutoCAD. Fig. 6 gives a screenshot of the software; a front facade detail is used as background in order to draw stained glass windows.

Based on existing projections, new grids can be easily generated. First, if the resolution is not enough in a part of the grid, the architect can generate a new grid with higher resolution for all the projection or a part of it (rectangle selection). For the same plane of projection, several grids can be loaded together in the software. Nevertheless, if the resolution is too high with respect to the points mean distance of the original point cloud, a lot of empty grid elements (i.e. transparent/background color (black by default) image pixels) will be present and this is not interesting. Secondly, it is also possible to generate a new grid that is perpendicular to the current projection only by drawing a line that corresponds to a vertical plane. So, the architect can easily manipulate and generate new grids based on the existing ones that were e.g. mathematically obtained for facades (best fit plane). This operation is really easy for the architect because no hard 3D manipulation has to be done.

This software was intensively used by the City of Brussels in order to draw precise plans of the Brussels City Hall and all its facades (see Figs. 8 and 9).

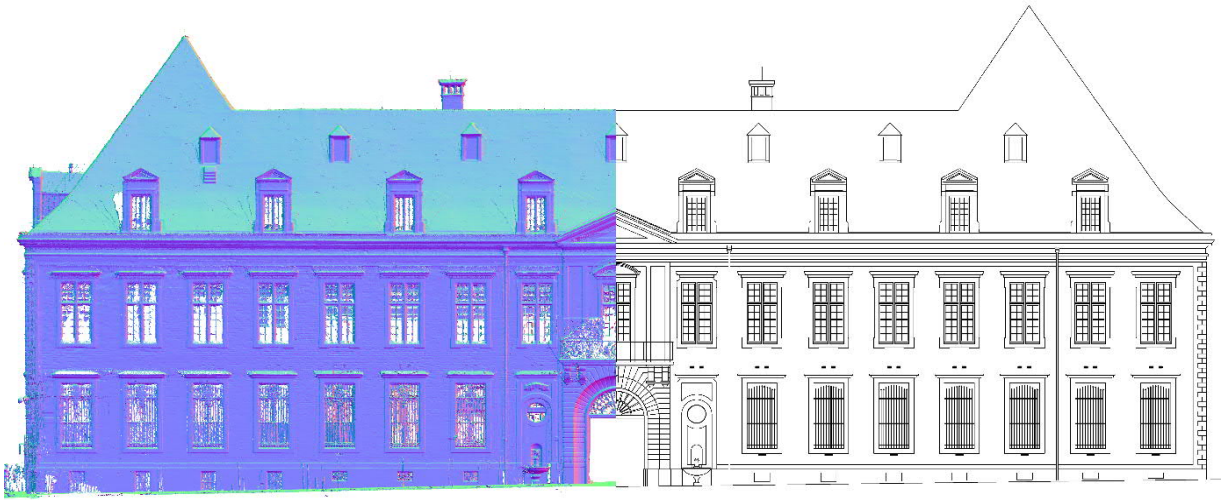


Fig. 8. Rear facade elevation: grid in normal color vs. drawing (©Ville de Bruxelles - Patrick Moureau's drawing)

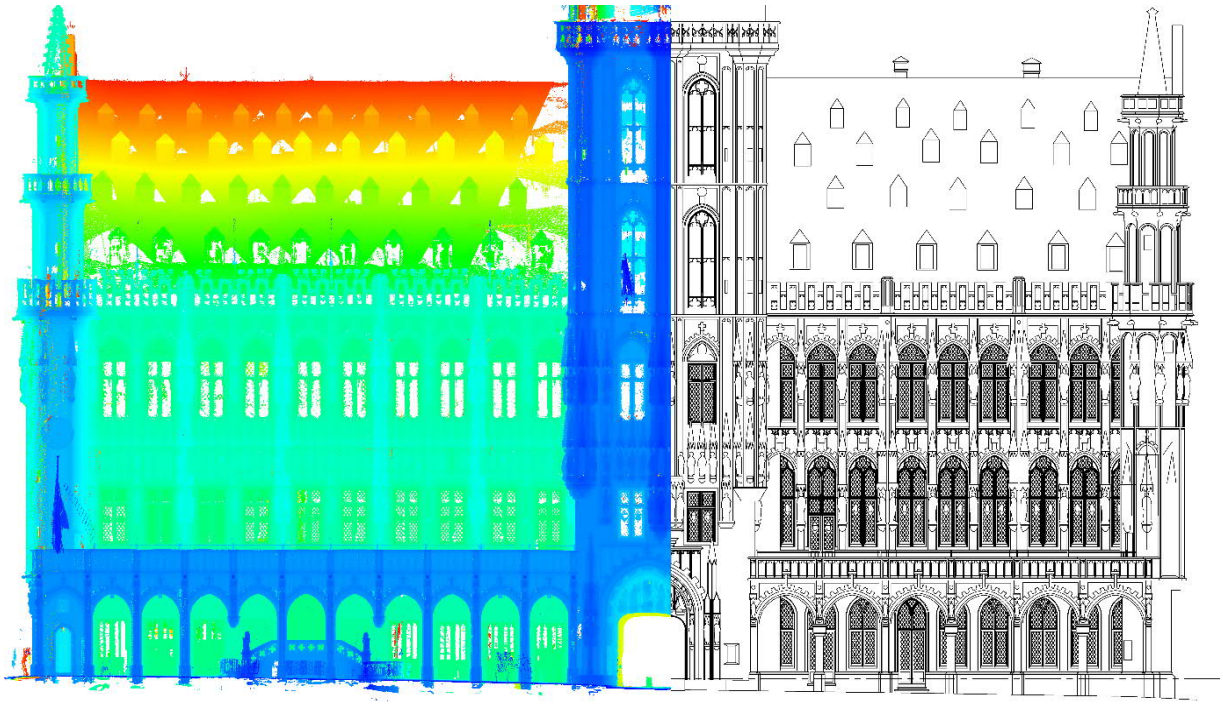


Fig. 9. Front facade elevation: grid in depth color vs. drawing (©Ville de Bruxelles - Patrick Moureau's drawing)

ARCHAEOLOGICAL EXPLOITATION

The developed software was also used with the archangel Michael scans, in order to generate projections in high definition giving complementary information for archeologists (see Figs. 10a and 10b) by placing elements, indices or hypothesis on these projections illustrating the research. Indeed, it allows archaeologists to draw the entire statue to the real scale and to distinguish the main work components with a better understanding of the articulations between its constitutive parts and the various transformations made to the statue over centuries. Moreover, the 3D model of the archangel statue was used as representations for videos and images but also to evaluate archaeological hypotheses: renderings of the original aspect of the materials (i.e. color restoration) (see Fig. 10c) or weapon

variations swapping. One hypothesis is that the sword killing the dragon may have been a spear (thanks to its dating), but the adapted model shows that it was not the case due to the wrong relative position of the dragon with respect to the spear (see Fig. 10d).

a *b* *c* *d*

Fig. 10. Exploitation of the archangel Michael 3D scans: a) front projection of the scans in normal color, b) side projections of the scans in normalized depth color, c) color restoration of the original statue, and d) sword replaced by a spear in the 3D model (draft rendering) in order to test this hypothesis

All these graphic documents are similar to an archeologist's survey, giving the material condition of the wind vane at a precise moment. They can support the restorers 'condition report and serve as a basis for an analysis prior to their intervention on site.

CONCLUSIONS

In order to carry out its architectural and archaeological study, a large part of the Brussels City Hall and some of its elements were digitized in 3D. The different scans were processed by an original pipeline for cleaning the erroneous points but also to correct the colorimetry of 3D points. Then, these data were exploited architecturally in the LisaCAD software in order to draw precise plans of the Brussels City Hall. In parallel, some data has been exploited by archaeologists to provide additional information to their studies as well as to verify certain hypotheses. LisaCAD helps archaeologists to better understand the archeological artefacts by adding different comprehension layers and establish next acquisition strategies and future planning of restorations. This project shows the interest of architects and archaeologists in using 3D digitization to understand a building or its elements as a whole in order to carry out an accurate study or survey and updates old data by correcting ancient plans using scanner technology.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the City of Brussels for their financial help in this interesting project, more particularly Professor Vincent Heymans, Mrs. Annick Schwaiger and Mr. Patrick Moureau. They also thank Mr. Pierre Anagnostopoulos of the "Société royale d'Archéologie de Bruxelles" for his contribution regarding the archeological exploitation of the archangel Michael 3D model.

REFERENCES

Arnaud Schenkel. 2017. Corrections géométriques et colorimétriques automatisées de modèles 3D de grande taille. *PhD Thesis*. Université Libre de Bruxelles. Belgium.

Thomas Kanzok, Falk Süß, Lars Linsen, and Paul Rosenthal. 2013. Efficient Removal of Inconsistencies in Large Multi-Scan Point Clouds. In 21st Intl. *Conf. in Central Europe on Computer Graphics, Visualization and Computer Vision*. Plzen. Czech Republic. p.120-129.

Reem Zeibak and Sagi Filin. 2007. Change detection via terrestrial laser scanning. In *ISPRS Workshop on Laser Scanning 2007 and SilviLaser 2007*. Espoo. Finland. p.430-435.

Adam Baumberg. 2002. Blending Images for Texturing 3D Models. In *British Machine Vision Conference, 2002*.

Marco Callieri, Paolo Cignoni, Massimiliano Corsini, and Roberto Scopigno. 2008. Masked photo blending: Mapping dense photographic data set on high-resolution sampled 3D models. *Computers & Graphics*. 32(4):464-473.

Ruggero Pintus, Enrico Gobbetti, and Marco Callieri. 2011. Fast low-memory seamless photo blending on massive point clouds using a streaming framework. *Journal on Computing and Cultural Heritage*. 4(2) article No. 6.

Arnaud Schenkel and Olivier Debeir. 2015. Comparison of normalized transfer functions for fast blending-based color correction of scans acquired under natural conditions. In *2015 Digital Heritage International Congress*. Grenada. Spain. p.127-130.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz
The editor's office is not responsible for the linguistic correctness of the manuscripts.
Authors are responsible for the contents and copyrights of the illustrations/photographs.

The Bellini Museum's Gallery: From Tradition to Present Time Using Digital Documentation

FRANCESCA SOLINAS and LUCA ALBERGONI, University of Florence, Italy

The Bellini family has been one of the most prestigious Florentine antique collectors since the 17th century to the present time. Their gallery is aimed to preserving the collections in the wake of the great Florentine Case Gallerie antiquarie (galleries and auction houses) that arose between the 19th and the 20th centuries and therefore witnesses the Florentine historical legacy. Located in Lungarno Soderini the museum overlooks Ponte alla Carraia. In modern times it has undergone various reworkings before adopting the current configuration through the work of the architect Adolfo Coppedé. The analysis of the building moves from a historical and cartographic research on archive sources and it relies on bibliographies. It has been articulated in two survey campaigns which involved the use of the photogrammetry and 3D Lasers Scanner. Following a specific request by Prof. Bellini, a subsequent campaign was furthermore carried out using a 360 degrees panoramic video-photography of the galleries on the two levels of the building. At a later stage, the collected data have been processed to obtain a three-dimensional texturized reconstruction of the main elevation and the point cloud of the entire building. This has been followed by the restitution of the high-resolution orthophoto of the façade and of the geometric survey of the structure, with the identification of its material characteristics and critical situations. In the final phase of the project hypotheses of intervention are proposed to respond to regulatory requirements, maintaining and enhancing the two current functions of the building: the contemporary art gallery and the antique gallery.

Key words:
Florence, Bellini Museum's Gallery, 3D Laser Scanner, Photogrammetry, Virtual Tour 360°.

CHNT Reference:
Francesca Solinas and Luca Albergoni. 2018. The Bellini Museum's Gallery: From Tradition to Present Time Using Digital Documentation.

INTRODUCTION

The Bellini Family is carrying on with the Galleria the memory of a special moment in time for antique trading and for the cultural aspect of the city of Florence. The Bellini's name is amongst some of the great names that between the 18th and 19th century represented the golden era of Italian antique trading. They projected their activity into the new millennium unlike other more renowned antique dealers. With the idea of perpetuate this operation the work of the thesis, from which this paper comes, is divided into two main paths: on one hand getting to know the fascinating building hosting the Galleria, and on the other one updating the educational and commercial activities by conjoining them with the opportunities offered by new technologies.

HISTORICAL BACKGROUND OF THE MUSEO GALLERIA BELLINI[1]

The Palazzina Bellini (Fig. 1), whose architecture is a key element of the Lungarno Soderini in Florence, owes its current appearance to the Bellini's, an important family well known for dealing antiques since the second half of the18th century [Bellini 1947; 1961; Bargellini 1981] who bought the building in the 1920s and turned it into a private gallery in order to preserve and exhibit their own collection.

Author's addresses: Francesca Solinas, Dipartimento di Architettura, University of Florence, Piazza Ghiberti, 21, 50121, Florence (FI) Italy; email: francesca_solinas@yahoo.it; Luca Albergoni, Dipartimento di Architettura, University Of Florence, Piazza Ghiberti, 21, 50121, Florence (FI); email: luca.albergoni@gmail.com.

[1] Homepage of Bellini Museum's Gallery. https://www.galleriabellini.com/ (Visited on 16/02/2018)

Fig.1. Main front of the Galleria Bellini, toward Arno River

The few sources regarding the building's history available today are not enough to pinpoint either an approximate date of the construction of the building or the author of the decorative and architectural aspect it resembles today. The documents discovered in various archives show the presence in the building of Augusto Burchi's studio (Florence 1853–1919) [Galardelli 1909], whose name appeared also on a few permits[2] given by the City of Florence in 1902 regarding construction works in the Gallery.

At the time, Augusto Burchi was one of the most important decorators in Florence. He was active in works of restoration and mural decoration, especially from the end of the 1880s until the first decade of the 1900s [Branca and Caputo 2017]. In 1901 Anita, daughter of Augusto Burchi, married Aldolfo Coppedè (Florence 1871–1951), third son of Mariano Coppedé, founder in 1885 of "La Casa Artistica di Mariano e figli Coppedè", a lab for the production of sculptures and wooden furniture, which had great success at the time. Adolfo, after having some experience as a painter, approached architecture [Bossaglia and Cozzi 1982; Cozzi 1996] and became an important exponent of Florentine and Italian post-eclecticism.

Even though there is no definite information regarding the Palazzina of Lungarno Soderini, it is possible to state that it was a focal point for important figures in the city's artistic culture at the beginning of the 1900s. It is therefore quite plausible that Augusto Burchi participated in the decoration of the façade and that Adolfo Coppedè contributed to design the façade and the rearrangement of the Palazzina Bellini.

Such intervention is datable around a period that goes from 1912 to 1920: even if we have Mauro Cozzi's testimony [Bossaglia and Cozzi 1982, p. 265] that the work took place in 1912, in the land register map from 1913-1920[3] the building looks unchanged in its form and only in the chart of 1968[4] it appears in its current state.

The lack of intermediate maps prevents for more precise dating.

ANTIQUE TRADE IN ITALY AND THE BIRTH OF GALLERY-HOUSES BETWEEN THE 1800s AND 1900s

The 19th century, the golden era of antique trading, represents a period of exceptional development which brought the eminent antique collectors' names, in particular the ones from Florence, an international recognition.

[2] "con richiesta, il 23 maggio 1902, da parte del decoratore del permesso di costruire un terrazzino in aggetto allo stabile n. 1 di Lungarno Soderini". Coll. CF7973, fasc. 14 m. ins. 90 m. The Historical Archive of the City of Florence preserves the documents produced and received by the city administration since 1781. http://wwwext.comune.fi.it/archiviostorico/index.html?pa=eventi_2013.html

[3] The Historical Archive of the City of Florence

[4] The Historical Archive of the City of Florence

The causes of this boom are to be found in a blend of heterogeneous factors, social-economic, artistic and religious ones. From the second half of the 1800s in particular, Florence was the destination of a cultured international tourism, originating from the interest of the intellectual European and American elites towards Italian art – the Renaissance one in specifically – and by a contemporary regain of the *"gusto dei primitivi"*. Following this "new" attention towards Italy and its art, a prestigious economical and cultural antique trade blossomed, aiming to satisfy amateurs and collectors from the wealthiest backgrounds and meet the growing demand for antique goods. Under these circumstances, a few Florentine antique dealers emerged as important figures – Luigi Bellini among them – that managed to act as mediators between an excessive offer produced by Italian public auctions and as a big growing demand from rich intellectuals and museums (both private and public, European and American).

People as Stefano Bardini, even though of humble origin, became in a short time a relevant figure in the market, creating a meeting point between Italy and the rest of the world. Their gallery-houses were a crossroad for intellectuals, artists and enthusiasts, places of debates, discussions and trading.

To them, we owe a unique example of the organization of these structures based on a new model of "home-museum-shop", with their settings becoming a model to other important museums in Europe and outside of Europe as well [Mannini 2011; Teodori and Celani 2017; Ferrazza 2017].

THE HISTORICAL EVOLUTION OF THE BUILDING

With the aim to date the building, one of the first phases of this work has been the search for maps and documents.

The research took place primarily at the State Archive and in the Historical Archive of the City of Florence[5]. Other than the historical cartography, the goal was to recover material which documented the creation and the development of the building at hand.

Taking as "moment zero" the construction of Palazzo Soderini (15th Century)[6] which overlooks Via Della Carraia – today Via Borgo San Frediano – the lot was occupied by it and, in the pertinent rear area, by its garden. The first construction of the side facing the Palazzina of Lungarno is attested by the Leopoldino Cadastre from 1833[7] (Fig. 2a) where a building, similar to the current one, appears for the first time even though of smaller size. From this first phase the building appears without variation both in the cadastral map from 1884[8] (Fig. 2b), and the one from 1913–20 (Fig. 2c) till the chart from 1968 (Fig. 3a) where it is finally attested in its current size.

a *b* *c*

Fig. 2. Historical cartography, details: a) Map of the Leopoldino Cadastre (1833); b) Cadastral Map of 1884; c) Cadastral Map of 1913-20

[5] The State Archive of the City of Florence conserves archives and original documents of historical interest (sec. VIII-XX) and ensures its consultation for study and research purposes. http://www.archiviodistato.firenze.it/asfi/index.php?id=2 (Visited on 16/02/2018).
[6] Il Repertorio Delle Architetture Civili di Firenze is a project whose objective is the census of the civil buildings present within the area inscribed by UNESCO on the World Heritage List. http://www.palazzospinelli.org/architetture/
[7] The Historical Archive of the City of Florence
[8] The Historical Archive of the City of Florence

From both the map and documentation research combined it could be affirmed the possibility that the building had at least two phases of extension.

This hypothesis is supported both by online research, through the system of the Historical Regional Cadastre (Ca.Sto.Re)[9] of the Tuscan region, and by the analysis of the decoration of the building itself.

a *b*

Fig. 3. a) Cadastral Map of 1968, detail; b) Image taken from Ca.Sto.Re System

Ca.Sto.Re allowed a first confirmation regarding the growth in size of the building, from how it appears the first time in the map from 1833, to the current state (Fig. 3b). In the system the two charts, the one from 1868 and the current one, are shown overlapping, highlighting an enlargement of the building, downsizing the internal courtyard. In the lack of further documentation, it is possible to consider another element of hypothesis for the building's growth: the analysis of the decorations brought on both for the internal and for the external.

One of the first noticeable things inside the Bellini museum-gallery is an evident coexistence of at least three different types of decorations, divided into three well recognizable styles.

a *b*

Fig. 4. a) The entrance corridor on the ground floor, an example of neoclassicism Poggiano style; b) Decoration's detail of the main façade: allegories of Painting and Architecture.

[9] Promoted by the Tuscany Region, the CA.STO.RE project involved the digital reproduction of over 12,000 nineteenth-century cadastral maps freely consulted online. http://www502.regione.toscana.it/geoscopio/castore.html (Visited on 16/02/2018).

They indeed divide the ground floor of the building in three parts apparently belonging to three different worlds, three diachronically different eras: the neo-classical era, typical of a "poggiano" context as the one of Florence (Fig. 4), a medieval-like area and one where neo-romanesque and neo-gothic elements alternate each other. From this analysis a "decorative scheme" was defined, it suggests that there were at least two phases of development in the building.

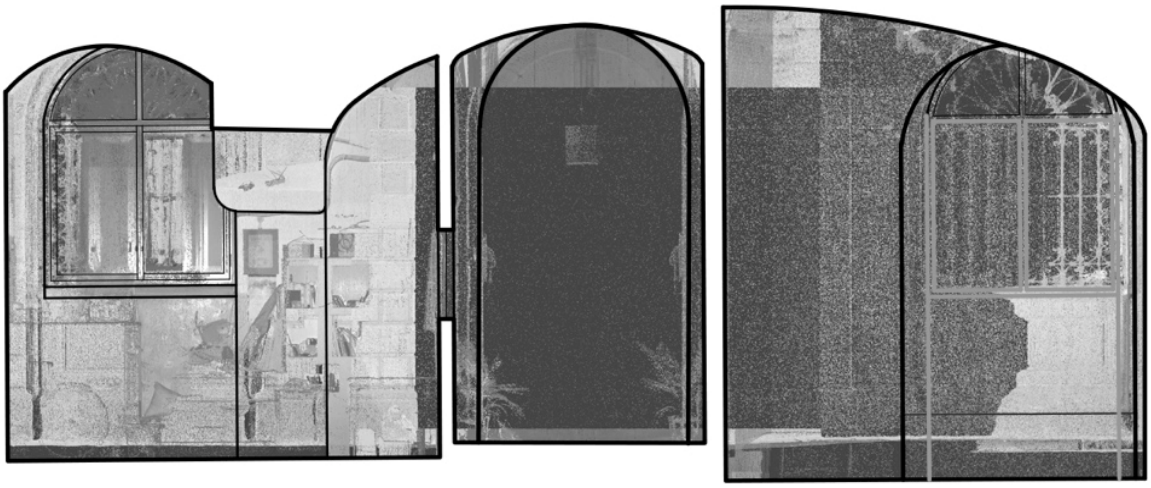


Fig. 5. Detail of the section obtained through a 3D Laser scanner that confirms the presence of an original vault, divided and partly covered by subsequent interventions

Fig. 6. The campaign carried out with 3D Laser Scanner on the Gallery's first floor

A first phase that can be described as “revival historicism” sees the decorative apparatuses, the ones in the "medieval style" together with a variation of neo-romanesque and neo-gothic elements. Through the direct observation and the mapping with the 3D Laser scanner it is possible to deduce that the central space on the Lungarno Soderini had a uniform purpose and was covered by a flattened barrel vault, later divided in interventions (Fig. 5). This suggests that the two rooms adjacent to this space were the accesses respectively to the private area and the commercial one of the rest of the building. A second phase sees the final renovation – presumably the work of A. Coppedè – and can be summarized in two macro-interventions: the shifting of the constituent axis and the renovation of the façade.

THE MAPPING CAMPAIGN

The mapping campaign of Palazzetto Bellini was carried out with 3D Laser Scanner and with photogrammetry. This double methodological choice is justified by the geometrical richness of the building and aims to its precise portrayal through a 3D digital model with high-resolution textures.

The use of the 3D Laser Scanner (Fig. 6) generates a digital three-dimensional object, very detailed in its geometry. To this day, this is the best technology available to render a model with the least amount of differences possible in relation to the real geometry of the object. The overall result of the campaign consists of 183 scans acquired in three days between February and June 2017.

Due to the presence of a centennial wisteria alongside the balcony – which during its blossoming would have increased the occlusion of the balcony – the first scans have been taken from the façade towards Lungarno Soderini. The stations inside the house Gallery were done in two times and only concerned the ground and first floor, leaving out the private area of the building.

The equipment used, a 3D Laser Scanner model CAM/2 FARO 3D Focus and a second model Z+F imager 5006H, were provided by the DIDALABS System of the Dipartimento di Architettura of Florence University [Mandelli 2007, Bertocci and Bini 2012].

Aside from what already reported, there was a photographic campaign limited to the façade – using digital reflex photo-cameras with a tripod – in order to integrate the data recovered with the 3D Laser Scanner and create high-definition textures which could render the material and the decoration of the front in an efficient manner.

The shots were then processed with the *Agisoft Photoscan*[10] program to achieve photomaps. To facilitate the software calculation and minimize the next step, all the pictures were shot in a manner that would ease the editing process of the image once in the software. The photos were taken with a clouded sky and indirect light, minimizing the presence of shadows and therefore obtaining the most uniform lighting possible; the pictures were also taken following a linear path parallel to the façade, with superimpositions of around 1/3 images, guaranteeing a total coverage of the object and avoiding empty spaces.

To capture the details of the decorations on the tympanum, the use of a telephoto lens was necessary and therefore the camera shooting point was very far from the object. The equipment used in this phase was a Sony camera DSC–HX400V, a Nikon D5300 with telephoto lens Tamron F2.8\200 mm and a Nikkor F4 with 24\120mm zoom. All the equipment was provided by the “Architecture Photo Lab” (LFA) of the System DIDALABS, Department of Architecture. To collect further documentation, a campaign was launched with a Ricoh Theta S camera, which creates 360-degree panoramic videos and photos in high-resolution. The spherical pictures are obtained with a "folded optic" technology, with the ultra-compact and ultra-wide-angle lenses, projected and optimized specifically for this type of photographs *(theta360)*[11].

The panoramas were taken using a camera with a double wide-angle ultra-compact lens – with an angle of 180 degrees greater than a fisheye lens – and distributed to the two-prism sensors at 90 degrees. The visualization of the images goes through the specific app, available on the Ricoh website, both for the main OS and in mobile versions. All the pictures were taken minding not to include the operators inside the camera field. The camera was set on a tripod at the center of the space that was supposed to be photographed, in order to get the best visual angle possible. By using the specific function of the camera – which can be managed by support devices such as tablets and smartphones – the operators were able to distance themselves and take the pictures without being included. To film

[10] http://www.agisoft.com/ (Visited on 16/02/2018).
[11] https://theta360.com (Visited on 16/02/2018)

the videos, the device was set on a pole, managed by hand: increasing the distance between the camera and the operator, their presence in the video was limited.

Fig. 7. Example of equirectangular projection of a room on the gallery's first floor

This technique got the attention of Prof. Luigi Bellini, current owner and manager of the gallery, who manifested a fair interest towards the possibilities offered by interactive and multimedia technologies to enable the viewing of the pieces inside the expositions even at a distance, both through 360-degree panoramic pictures and with 360-degree video series (Fig. 7).

DATA PROCESSING

Point cloud processing with Autodesk Recap

The phase of connecting the several 3D Laser Scans of the point cloud processing was carried out with Recap Pro, a program by *Autodesk*[12].

The purpose of the software is to acquire and process .ZFS files from the Laser Scanner and converting them into editable three-dimensional data. The process has three phases: the importing of the single scans, their registration, and the indexing (unifying the scans into a single point cloud).

The data provided by the point cloud currently represents the closest information to reality, but it is also extremely distant from the traditional forms of representation (Fig.8). It is necessary to translate the three-dimensional data in bi-dimensional codified forms such as maps, perspective drawing, and sections.

To achieve this further step has been used a software by Bentley, *Pointools VI*[13], that allowed to optimize and edit the point clouds and to export screenshots of the model. Initially, the files have been converted by the use of Autodesk Recap into a format compatible with Pointools VI. The file obtained by the conversion is not composed by a group of scans but by a single cloud which provides a better management of the file itself (“not gripped”). Furthermore, the advantage reached by the use of this software is the possibility to identify section-plans geometrically defined by a triad of Cartesian axes (x, y, z) and by an axis rotating on z.

[12] https://www.autodesk.com/products/recap/overview (Visited on 16/02/2018)
[13] Homepage of Bentley Pointools, a software used to visualize, manipulate, animate, and edit point clouds. https://www.bentley.com/en/products/product-line/reality-modeling-software/bentley-pointools (Visited on 16/02/2018)

All of this allows to obtaining the desired sections with a geometrically precise result and data characterised by a high level of accuracy (Fig. 9).

Fig. 8. The final result: the total point cloud in Autodesk Recap

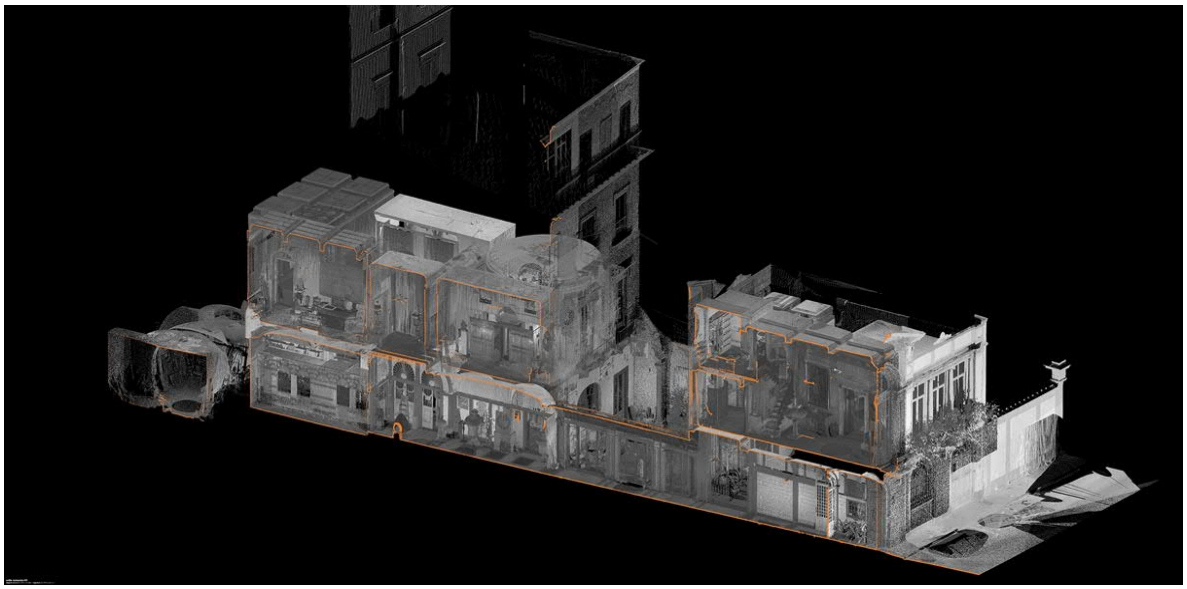
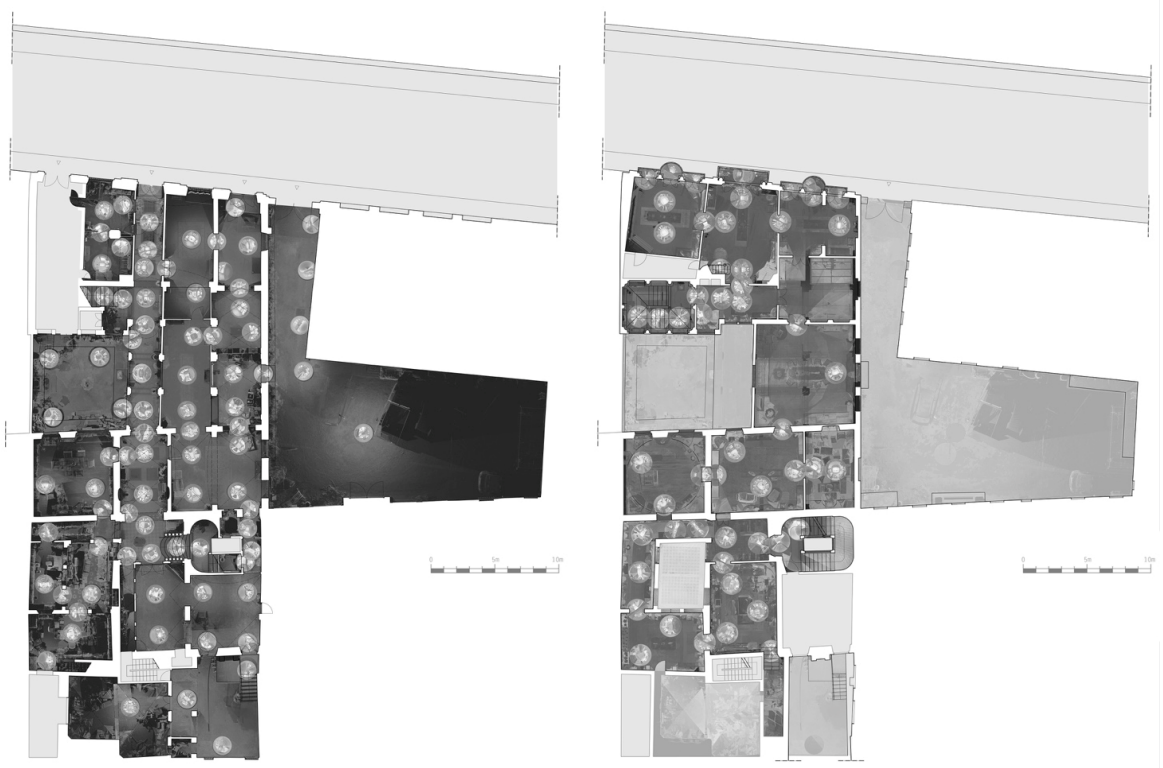


Fig. 9. The 3d model, cut with a vertical section-plane

Once the section plan is defined and the orthogonal view is oriented to the object to be rendered, it is possible to save the viewer window and export a screenshot of the model, defining the image size, the shot area, the format of the exported file, and its quality.



a *b*

Fig. 10. maps of the two levels of the Palazzina Bellini: a) the ground floor; b) the first floor

Fig. 11. longitudinal section

Once the image of the section was created the next step was to set the raster in an *AutoCAD*[14] file and start the following operation of review, thus obtaining maps, perspective drawings and sections of the object studied (Figs. 10-11).

Photomaps processing

In order to process the photomaps and a textured three-dimensional model, was used the Agisoft Photoscan software, version 1.3.

Fig. 12. Photomap of the main elevation.

The photogrammetry survey was limited to the façade of the building toward Lungarno Soderini and it was implemented with the purpose of providing evidence of its decorative and material richness. The data processing was complicated because the main front has many interference factors that prevented the software from easily recognizing the various elements. The first of the problems was the presence of a large wisteria plant alongside the whole façade, which wraps itself around the wrought iron balconies; an additional complication was represented by the size of the glass windows of the first floor and the reflections they produce.

The software has troubles recognizing and processing data coming from images in which there are at the same time both elements in motion blur – in this case, the movement of the wisteria branches – and reflecting surfaces of such size.

To fill in the gaps in the balcony area, we calculated a second model, achieved through distance shooting with a telephoto lens. In this case also, however, the model processing was not satisfactory, and the use of these images moved to the post-production phase and, with the use of Adobe Photoshop, the gaps of the first model were filled. (Fig. 12).

[14] https://www.autodesk.com/products/autocad/overview (Visited on 16/02/2018)

HYPOTHESIS OF INTERVENTION

The current situation

The building presents rich historical layers, which are evident from the variety of the areas and the heterogeneity of the decorations. Nonetheless, a series of individual interventions without an organic project was carried out during the years, altering the structure, degenerating its character, dividing its volumes improperly through false partitions, and obstructing its openings. In addition, there are the usual problems related to the lack of routine maintenance, with inevitable repercussions on the general health of the spaces and the preservation of the artwork.

Repair, maintenance, and upgrading of the spaces

The purpose of the project is to protect the charm of the spaces, improving the usability while respecting the double function of the building, the museum, and the commercial one. Restoring the health of the spaces also contributes to this aim, both for the users and for the artwork inside.

The procedures identified for the fulfilment of these goals can be divided into two types of interventions: one with a focus on the distributive upgrading through the removal of the several improper interventions of divisions, hollow walls and false ceilings; the other one consists of updating the systems to fit the current standards, respecting the charm and the historical character of the building.

Digitalization of the Galleria

The survey is an essential cognitive tool, a requirement for the consecutive analyses and a foundation for an efficient project proposal related to the issues of the building and its correct restoration (fig. 13). The use of 3D Laser Scanner technology ensured the quick elaboration of an extremely detailed digital model of the building's geometry and the current setting of the several rooms. The employment of panoramic 360-degree pictures offers a chance to create virtual reality tours, other than the rendering of colors, which is not completely accurate through the point cloud. These virtual tours can be taken through web platforms or applications, specifically developed in order to implement the usual advertising and information techniques, with a double effect of expanding the possible audience both of the museum and the antique artwork gallery. The possibility of creating virtual tours was welcomed by Prof. Bellini, who sensed the potential and the benefits of releasing the exposition from its physical place by connecting the traditional advertising methods of museums with modern multimedia technology.

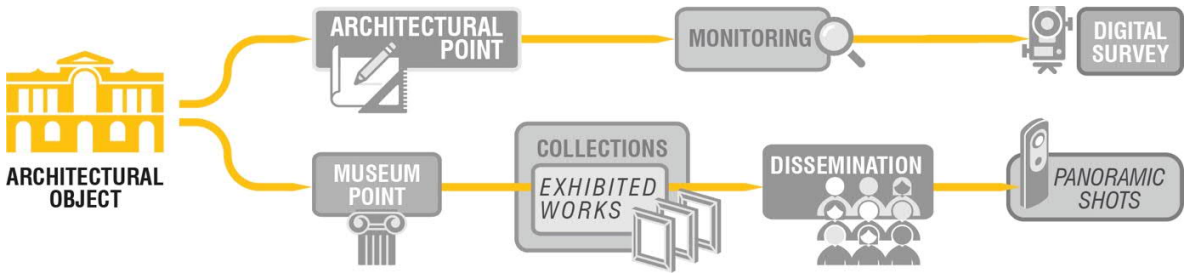


Fig. 13. Digitization process diagram

The number of museums and galleries that update and enrich the offer of their expositions, thanks to new technologies and the spreading of portable devices, is constantly growing, and the development of the various methodological approaches to the digitalization of their collections is even faster. The most popular trends can be summarized in two processes: one would be virtual tours which digitally recreate the architecture and setting of the galleries, and therefore put the artwork in a more or less immersive but fully virtual scenario. The other method would be to create actual catalogues of the collections, in which the artwork is rendered with the highest details, both bi and three-dimensional. This is the direction of platforms such as Sketchfab, which enables the viewing and fruition of three-dimensional models, with the possibility of being consulted remotely [Verdiani 2016]. In this

platform are included organizations such as the British Museum[15] or the Museum d'Arqueologia de Catalunya[16] that made part of their collections available to the website users.

The goal of the project is to connect the two examples in a single panoramic tour, based on 360-degree pictures, with the chance for the users to improve their knowledge of the artwork accessible through links to a virtual catalogue describing their characteristics in detail. Such method allows users to explore in only one tool both the gallery and the museum, and it is easily accessible from any available device, such as mobile phones, tablets or others (Fig. 14). For the realization of this project, a digitalization campaign was carried out using more than sixty photos and videos of the galleries on the two floors of the building.

After the post-production editing, the video material was uploaded to the web platform Vimeo, which accepts 360-degree videos and guarantees private viewing only to the users with a specific access code. The several 360-degree photos of the antique artwork Galleria on the first floor were assembled in a single tour that follows the sequence of the rooms through the *Panotour 2.5* software[17]; such a program enriches the value of the tour providing links to the pieces in the exhibition, leading to interactive elements. High-resolution images, animated GIFs, link to web pages, text documents and audio-visual elements can be uploaded to the package of files generated by the software. It is possible therefore to realize didactic cards with the characteristics of the pieces and connect detailed renderings of the painted areas or small turntable videos of the sculptures to the pieces themselves.

The tour can be downloaded directly on the visitor's smartphone and launched through the free *Panotour player*, or opened as an HTML app on a browser, accessible via a QR code.

Fig. 14. Interactivity and navigability of the panoramic virtual tour

[15] A page contains photogrammetric reproductions of works belonging to British Museum Collection. https://sketchfab.com/macb3d (Visited on 16/02/2018)
[16] A page contains photogrammetric reproductions of works belonging to the Museo d'Arqueologia de Catalunya. https://sketchfab.com/macb3d (Visited on 16/02/2018)
[17] http://www.kolor.com/2018/06/21/virtual-tour-software-panotour-panotour-pro-2-5-12-minor-update/ (Visited on 16/02/2018)

CONCLUSIONS

In conclusion the 3D laser scanner is a new technology implementing and improving traditional cognitive tools in regards to a building. In the case of the survey of Palazzina Bellini, the data obtained in the digitalization helped to reconstructing the historical evolution of the building, which was complex with such scarce documentation material. The scan highlighted the fact that the space on the ground floor toward the Lungarno was initially covered by a vault, that it had a uniform purpose and that the inside divisions and the false ceiling were the results of later interventions. After all the multimedia technologies allow to reach a new concept of a museum that goes beyond its walls and makes the fruition of the exposition and the immersion in places rich with history and culture available to a much wider audience.

Recently the video tour was used, for example, during the preparation for the exhibition “Miracle: the Bellini Family and the Renaissance” at the Himalayas Museum in Shanghai. On this occasion, the panoramic tour and the relative 360-degree picture were used as a tool for the training of the tour guides that accompanied the visitors of the exhibition. Through the multimedia reproductions, it was possible to let the guides experience the atmosphere of the Florence Galleria, in order to best render the charm of the artwork in their architectural context.

ACKNOWLEDGEMENTS

The author thanks Prof. Arch. Giorgio Verdiani and the DIDALABS System of the Dipartimento di Architettura of Florence University for the support provided to the project's development.

I thank Prof. Bellini for the opportunity provided, and his staff for their availability.

Finally I thank Dr. Mirella Branca and Prof. Arch. Gian Luigi Maffei for the support given in the reconstruction of the building's historical events.

REFERENCES

Simone Bargellini. 1981. Antiquari di ieri, Firenze: Bonechi Editore.

Luigi Bellini. 1947. Nel mondo degli antiquari, disegni di Giorgio De Chirico, Firenze: Arnaud .

Luigi Bellini. 1961. Il fascino dell’antiquariato, Firenze: Vallecchi.

Stefano Bertocci e Marco Bini. 2012. Manuale di rilievo architettonico e urbano. Novara: CittàStudi.

Rosana Bossaglia and Mauro Cozzi. 1982. I Coppedè, Genova: Sagep Editrice.

Mirella Branca and Annarita Caputo. 2017. Dai modelli decorativi tardo ottocenteschi alla cultura modernista e al mito eroico nella pittura murale: Augusto Burchi, Galileo Chini, Adolfo De Carolis. In Sandro Bellesi. Accademia di Belle Arti di Firenze. Pittura 1784–1915. Firenze: Mandragora, pp. 207–224.

Mauro Cozzi. 1996. Firenze e l’arte nuova. In Maria Adriana Giusti. Le età del Liberty in Toscana, atti del convegno (Viareggio 29–30 settembre 1995). Firenze: OCTAVO Franco Cantini Editore, pp. 90–98.

Roberta Ferrazza. 2017. Il Museo della Casa Fiorentina Antica, le aste del 1916 e del 1917 a New York e la diffusione dello ‘stile Davanzati’ nel mondo. In Brunella Teodori and Jennifer Celani. 1916–1956–2016 . Dall’asta al Museo. Elia Volpi e Palazzo Davanzati nel collezionismo pubblico e privato del Novecento, atti della giornata di studi (Firenze, Palazzo Davanzati, 21 novembre 2016). Firenze: Polistampa, pp. 15– 31.

G. Galardelli. 1909. Catalogo dei quadri, bozzetti, disegni e stampe esistenti nello studio di pittura del Cav. Prof. Augusto Burchi, Firenze: Galardelli e Mazzoni.

Emma Mandelli. 2007. Dati, informazione, conoscenza. Metodi e tecniche integrate di rilevamento. I modelli tridimensionali, la costruzione e trasmissione dei dati. Firenze: Alinea.

Lucia Mannini. 2011. Le stanze dei tesori. Collezionisti e antiquari a Firenze tra Ottocento e Novecento, catalogo della mostra (Firenze, Palazzo Medici Riccardi, 29 settembre 2011–25 aprile 2012). Firenze: Polistampa.

Antonella Nesi. 2017. Stefano Bardini ed Elia Volpi: due stili a confronto. In Brunella Teodori and Jennifer Celani. 1916–1956–2016 . Dall’asta al Museo. Elia Volpi e Palazzo Davanzati nel collezionismo pubblico e privato del Novecento, atti della giornata di studi (Firenze, Palazzo Davanzati, 21 novembre 2016). Firenze: Polistampa, pp. 249– 265.

Giorgio Verdiani. 2016. Ricostruire nel virtuale e nel reale, esperienze tra musei e divulgazione. In Anna Margherita Jasink and Giulia Dionisio. MUSINT 2, Nuove esperienze di ricerca e didattica nella museologia interattiva. Firenze: University Press.

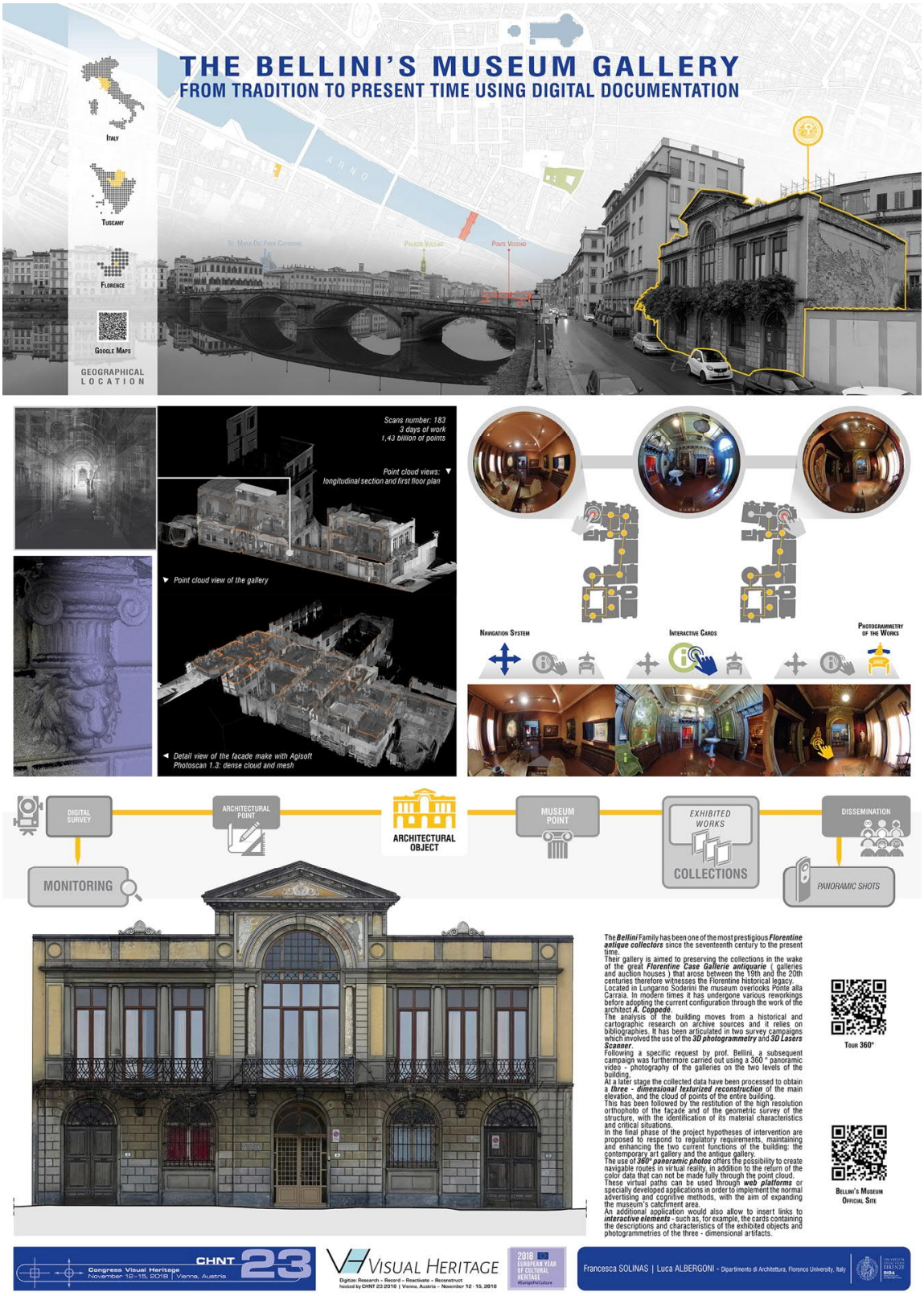


Fig. 15. The poster presented at CHNT

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz

Great Statues and Seismic Vulnerability – A Photogrammetric Approach for Early Safeguard

MARCO TANGANELLI, GIORGIO VERDIANI, and RAFFAELLA PAOLUCCI,
Dipartimento di Architettura, University of Florence, Italy

In recent years, more and more attention has been paid to create safeguard measures in protecting masterpieces, art items, and large statues, from the uncontrollable event of an earthquake [Agbadian et al. 1988]. In this paper a comprehensive analysis of a set of significant statues currently located in the Bargello Museum in Florence (Italy) is proposed. The work includes the geometrical survey of the object, until arriving to measure their seismic safety level. While the correct definition of the shape of the elements is fundamental in this processing, an attention will be given to the phase of the digital survey, here operated using photogrammetry based on Structure from Motion procedures. All the steps of the workflow will be analyzed and described in its main issues, lessons learned, new procedures. A set of different procedures will be compared, a brief method based on a 50 MP resolution camera with high quality optic and highly accurate modeling and its integration with direct measurements and/or 3D Laser Scanner Survey. The results of the procedures will be matched to the results of the simulation analysis, suggesting affordable approaches for any similar conditions about the interpretation of the state of safety of this important cultural heritage.

Key words:
Photogrammetry, Statues, Bargello Museum, Seismic Vulnerability, Resilience.

CHNT Reference:
Marco Tanganelli et al. 2018. Great Statues and Seismic Vulnerability – A Photogrammetric Approach for Early Safeguard.

INTRODUCTION

This work has been developed within the *RESIMUS* Research Project: *"RESIMUS, un progetto volto alla vulnerabilità sismica delle opere museali"* [Viti 2018]. Its multidisciplinary approach has the goal to combine different knowledges in order to prevent risk to the museum's collections in case of earthquakes. The same working method, characterized by the collaboration and the comparison between different professions, was applied to Giambologna's statue of Oceano, now located under the vaults of Bargello National Museum, in Florence and to the homonym fountain in Boboli Garden, where it was originally placed.

The Bargello Museum is an exceptional and privileged case study, both for the importance of the exhibited collections and for the variety of settings used. Even Boboli Garden has similar properties, since it is one of the most important examples of Italian garden in the world and is a real open-air museum, for the architectural-landscape setting and for the collection of sculptures, ranging from antiquity Roman to the 20th Century.

Starting from the application of this method to previous case studies, such as Ammannati's Juno's Fountain [Cerri et al. 2017], Donatello's Marzocco [Mattoni and Tanganelli 2018] and also referring to the first significant contributions in this direction [Lowry et al. 2007; Parisi and Augenti 2013; Wittich et al. 2016; Spyrakos et al. 2017; Gonizzi Barsanti and Guidi 2017; 2018], the work was analyzed in compliance with the guidelines for monumental heritage [BBCC 2010], in order to guarantee its preventive protection in case of seismic events.

Authors addresses: Marco Tanganelli, Dipartimento di Architettura, Università degli Studi di Firenze, Piazza Brunelleschi, 2, 50121, Firenze (FI) Italy, E.mail: marco.tanganelli@unifi.it; Giorgio Verdiani, Dipartimento di Architettura, Università degli Studi di Firenze, via della Mattonaia, 8, 50121, Firenze (FI) Italy, E.mail:giorgio.verdiani@unifi.it; Raffaella Paolucci, Dipartimento di Architettura, Università degli Studi di Firenze, Piazza Ghiberti, 27, 50121, Firenze (FI) Italy, E.mail: raffaella.paolucci@stud.unifi.it.

As recent seismic events proved that artistic goods are very vulnerable to earthquakes, research communities are starting to focus their attention on the preservation of museum's collections. The peculiar vulnerability of freestanding structures, namely statues, were slenderness is the main characteristic, remarks the need to understand their behavior and develop reliable tools to predict their response to seismic loads. Here the first results from this research while it is still ongoing.

THE HISTORICAL RESEARCH

In the middle of 17th century Florence was one of the capitals of the artistic and architectural culture, known all over the world as the capital of Renaissance. In these years, a great work of transformation and embellishment of the city was carried out. The protagonists of this venture were Giorgio Vasari and Bartolomeo Ammannati, under the aegis of Cosimo I de' Medici. Both architects contributed to the transformation of Palazzo Vecchio and Palazzo Pitti, where Cosimo established the base of his government and life.

In 1565 and 1567 Cosimo I commissioned two large fountains for Boboli Garden, depicting *Nettuno* and *Oceano* to be placed on the main axis of the garden to celebrate his person and Medici dynasty power (Figs.1 and 2). The sequence of the two fountains was certainly not a casual event but perfectly designed to exalt the two components necessary for Cosimo to govern: the warrior and determined temperament, recognizable in the angry *Nettuno* of Stoldo Lorenzi and the ability to dominate the lands conquered with justice and magnanimity, clear in the peaceful *Oceano* by Giambologna, our case study. [Medri 2003; Soldini 1976; Paolozzi Strozzi and Zykos 2006]. At the center stands the statue of *Nettuno*, commonly called *Oceano*, surrounded by lying river gods that represent the Nile, the Ganges and the Euphrates, which symbolically pour their waters into the large basin, which represents the Ocean. The two large fountains occupied their original position until 1590 when they were moved to the current location, because of the transformation of that area of the garden in a stone theater. In the same period, Bartolomeo Ammannati was realizing his Fountain of Neptune in *Piazza della Signoria*. (Fig.3). In 1559, Cosimo I de' Medici launched a competition to design a fountain at a time when a new aqueduct was also being built, the first to bring running water to the city. The plan was for a statue of *Nettuno* as the primary element, in a chariot drawn by sea-horses, symbolizing Florence's command of the Mediterranean. Initially, Baccio Bandinelli was the sculptor chosen, but he died before work began. Sculptor Ammannati was hired to take over and completed the work with assistants and collaborators. The face of *Nettuno* is said to resemble that of the Grand Duke Cosimo.

Fig. 1 Stoldo Lorenzi's Neptune in the Boboli Garden, Florence. (Photo: Marco Giorgi)

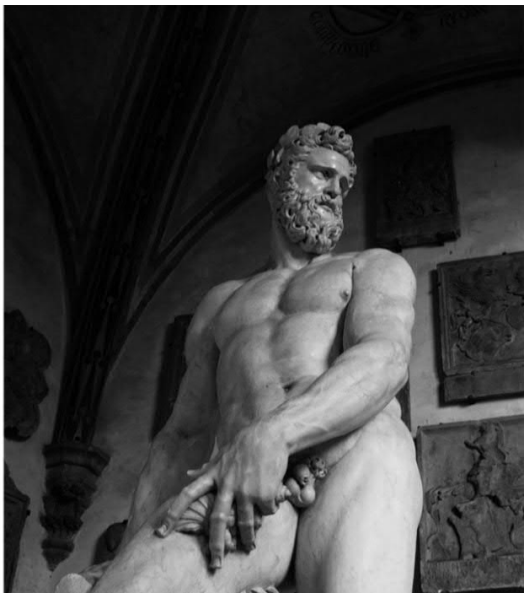


Fig. 2 Giambologna's Oceano, in the Bargello National Museum, Florence. (Photo: Laboratorio Fotografico di Architettura)

Fig. 3 Bartolomeo Ammannati's Neptune realized from 1560 to 1565, also known as "Biancone" (the big white guy) (Photo: Raffaella Paolucci)

SURVEY METHODOLOGIES AND DIGITAL MODELS

According to the considerations emerging from the RESIMUS project, the seismic assessment of artifacts requires an accurate preliminary representation of the object, because only an accurate representation can provide reliable results in terms of seismic assessment. With the cooperation of the Photographic Laboratory of DIDALABS[1] we made two photogrammetric surveys, respectively of the original Oceano statue, conserved at the Museum of Bargello, and of its copy, within the Fountain in the Palazzo Pitti Garden. For both the statues a 3D laser scanner survey was used to better support the scaling and completion of the photogrammetric operations. In the case of the statue at the Bargello Museum it was used a partial lasergrammetry, previously taken in 2011 during the operation on the digitalization of the "Fontana di Sala Grande" [Verdiani et al. 2012]. For the "Fontana dell 'Isola" a new set of scans was done in October 2018. Finally, different types of seismic analysis were conducted on the two models obtained with the survey campaigns.

PHOTOGRAMMETRIC SURVEY

In line with the procedures of "Structure from Motion/Image Matching" (SfM/IM) [Guidi et al. 2015] software, which is the well-known process of reconstruction of the shape of an object through the collimation of points from a set of photos, the model of the copy of Oceano was obtained using *Agisoft Photoscan*[2]. Instead, for the model of the fountain it was preferred to operate using *Reality Capture*[3]. Although the workflow from the photos to the creation of the final 3D model is substantially the same for both software, the changes introduced by the superior operative speed of RC in all the data processing, made more interesting the use of Reality Capture. A hypothesis about using

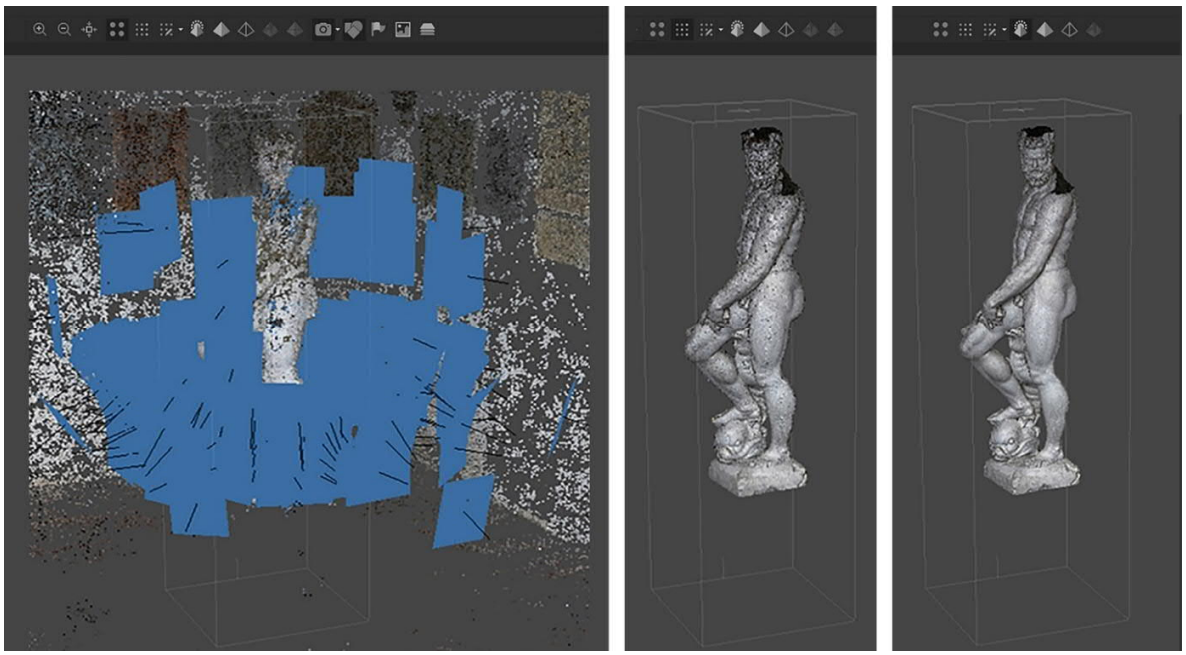
[1] Group of several laboratories of the Department of Architecture
[2] https://www.agisoft.com/
[3] https://www.capturingreality.com/

the similar function offered by *Autodesk Recap*[4] was taken into consideration, but it was not completed because of the quite unpractical need of total upload of the picture set to the Autodesk server.

The first step to obtain an effective alignment is the correct image shooting. The SfM/IM software extracts the remarkable points from the photos (that it calls "cameras"), then it derives the photographic parameters and finally crosses the recognizable points on more photos finding the coordinates of the points in the space. Since the minimum number of photos that the SfM/IM can automatically collimate is three, for each point are required at least three offset and stackable images. Subsequently, the alignment of the chambers produces two point-clouds, first a sparse one, then a dense one, with a significantly higher number of points. From the dense cloud a mesh is created and then a UV mapping on which the texture of the object is generated and applied.

For the Oceano model, 140 shots were used from the 152 images taken with a Fujifilm GFX 50S a Mirrorless, Medium Format, with a resolution of 51 MP, mounting a Fujinon GF 32-64mm F4 R LM WR zoom lens and a SONY α7R mirrorless, full frame, with a resolution of 36,4 MP, mounting a Sony FE 24-70mm F4 ZA OSS They generated a sparse cloud of 268.605 points, a dense cloud of 83.000.000 and a polygonal mesh of 16.630.000 triangles (Fig. 4). The main issues in the shooting of this statue were the height of the statue itself. In facts, while it was not allowed to arrange a scaffolding (neither a ladder) around the statue, a high tripod and some "acrobatic" positioning were the only solution to allow a good coverage of the whole statue. For this same reason, having in mind the even higher statue in the Boboli Garden, the photographers preferred to use a lighter camera for the shooting of this second statue.

Then, for the "Fountain of the Island" 437 shots were taken using a Pentax K-1, CMOS Full-Frame, with a resolution of 36.4 MP, mounting a lens SIGMA 35mm, F1.4 DG HSM and a SONY α-7R Mirrorless, Full Frame, with a resolution of 36.4 MP, mounting a Sony FE 24-70mm f/4 ZA OSS zoom lens. These two cameras, despite the excellent lens and sensor quality, offer very good connectivity and allow a full remote control of the shot. Their low weight and easy balance make quite simple to operate them on a pole or a very high tripod. Using a high tripod, extended to its maximal height (2,1 m) and with two operators rising it up, it comes out as a simple and well working solution for all the shooting in the Boboli Garden.



a b c

Fig. 4. Elaboration of the model in Agisoft Photoscan: a) spare cloud with cameras; b) dense cloud; c) mesh model

[4] https://www.autodesk.com/products/recap/overview

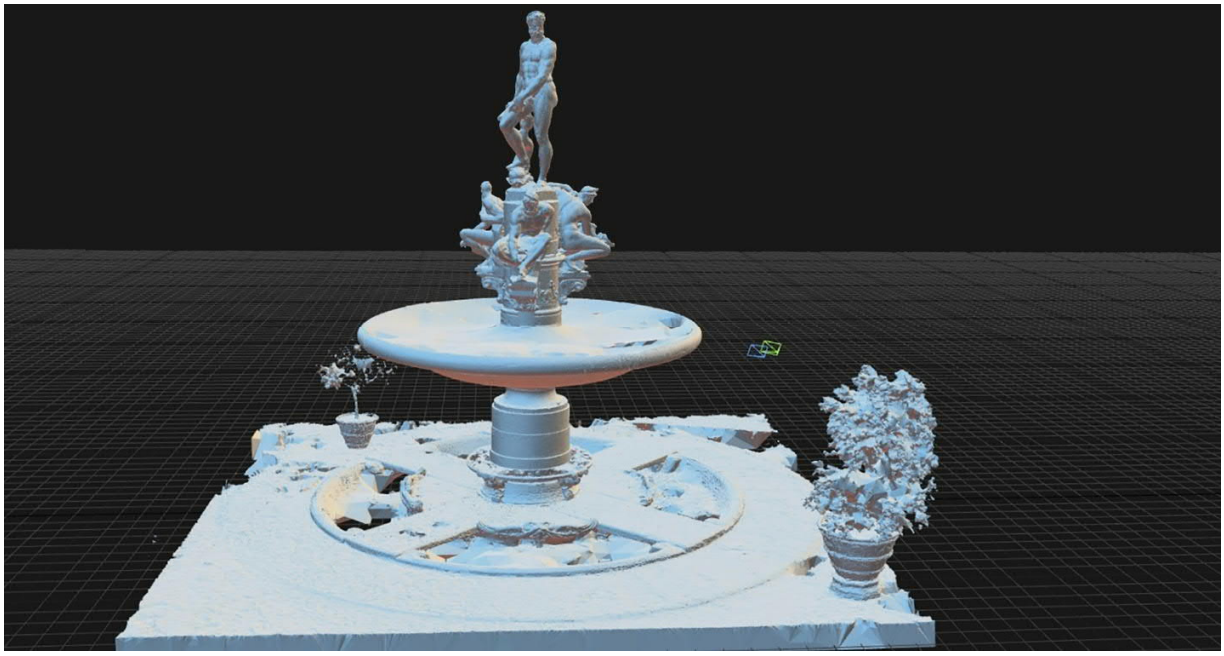


Fig. 5. Surface model of the Oceano's Fountain obtained in Reality Capture

Fig. 6. Textured model of the Oceano's Fountain with cameras, generated in Reality Capture

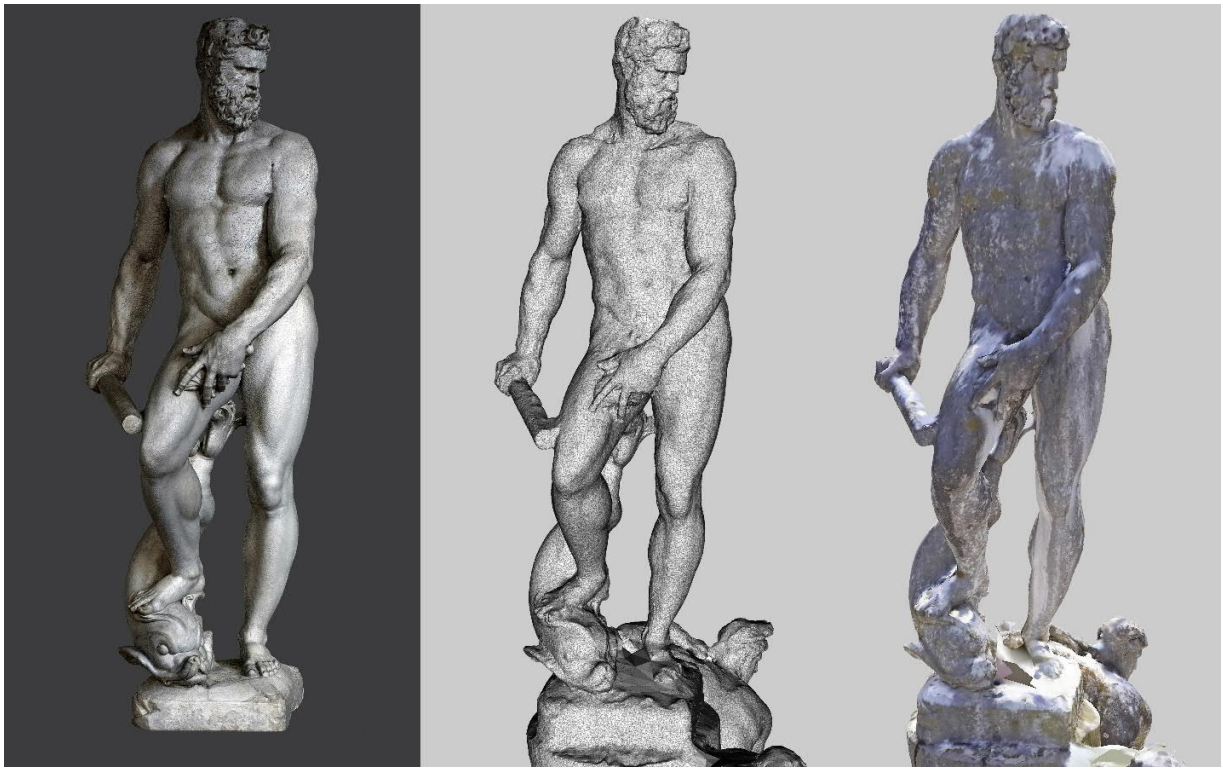


Fig. 7. Comparison between Oceano's original copy and its copy on the fountain

In a couple of hours, the whole work was done. From a sub-selection of the shots (402) the photogrammetric processing generated a cloud of 2.429.000 points and a polygonal mesh of 159.000.000 triangles (Figs.5 and 6). Since at the time of the survey campaign the fountain basin was full of water, its internal profile was rebuilt with the *Mcneel Rhinoceros 6 software*[5], making assumptions about its hypothetical geometry shape.

3D LASER SCANNER SURVEY

To integrate and complete the photogrammetry of both the statues it was preferred to use a specific lasergrammetry. The scans of the *Oceano* from the Bargello Museum were recovered from a previous survey, made in 2011 and covering a large part of this statue. (Fig.10). The subject of the scanning was the group of statues belonging to the "Fontana di Sala Grande" by Bartolomeo Ammannati, but the use of a full panoramic Scanner, produced the secondary gathering of a large part of Neptune, just at one bay of distance. The scanner used at that time, a Cam/2 Faro Photon using phase shift measurement technology, was a good solution, probably not the best on marble, but efficient enough to produce a full usable contribution for the scaling of the photogrammetry of the statue.

In the case of the "Fontana dell'Isola" the lasergrammetry was operated using a Cam/2 Faro X330 Phase shift model, a quite interesting unit, with a measuring range up to 330 meters. With such a range it was possible to take the measurement of the whole fountain and of all its surroundings.

The creation of such a large model when working on a statue is due to the intention of having some elements in more for evaluating the general design and asset of the island, the real section of the ground and the relationships between nearby trees, open spaces (all interesting data for studying the effective exposition to the weather and to the wind of this monument). In a certain sense a set of data for further study were put apart.

The scan of the fountain was done in 24 scans, 8 taken from a distance of about 10 meters from the fountains; 8 taken from a distance of about 20 meters, 4 at close range, from low points around the base and 4 from a distance of about 50 meters.

[5] https://www.mcneel.com/it/products

Fig. 9. 3D Laser scanner survey of the "Fountain of the island" in the Boboli Garden

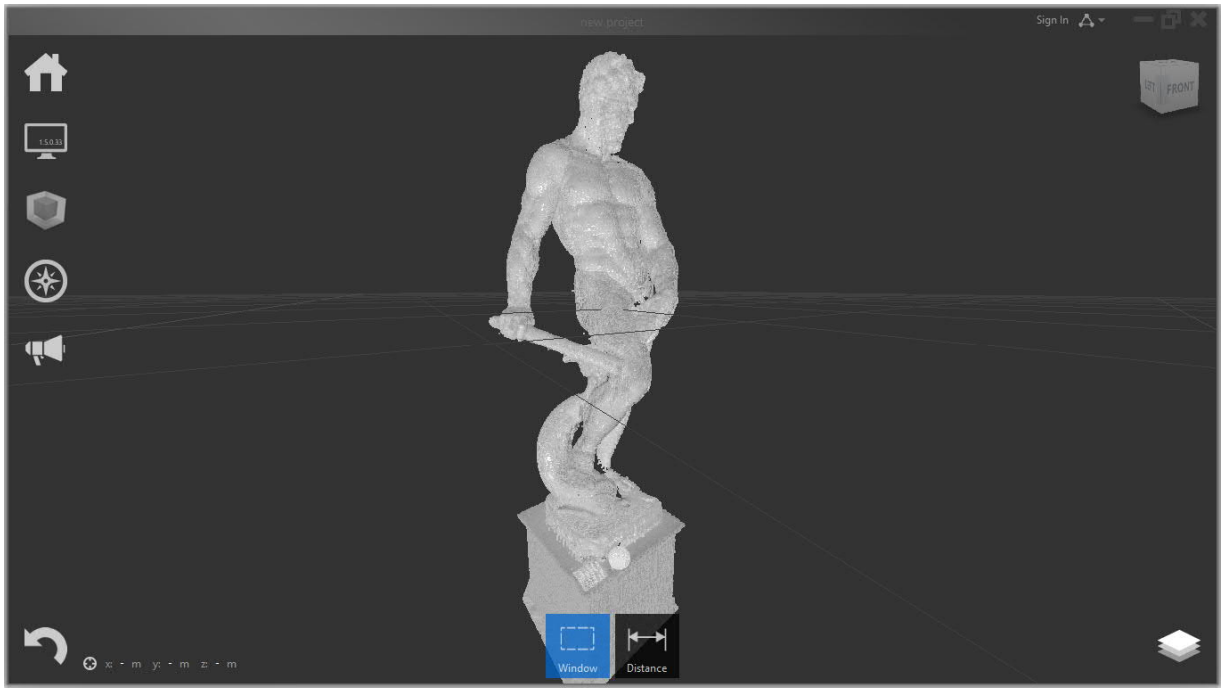


Fig. 10. 3D Laser scanner point cloud of Oceano recovered from 2011 survey in the Bargello Museum, Florence

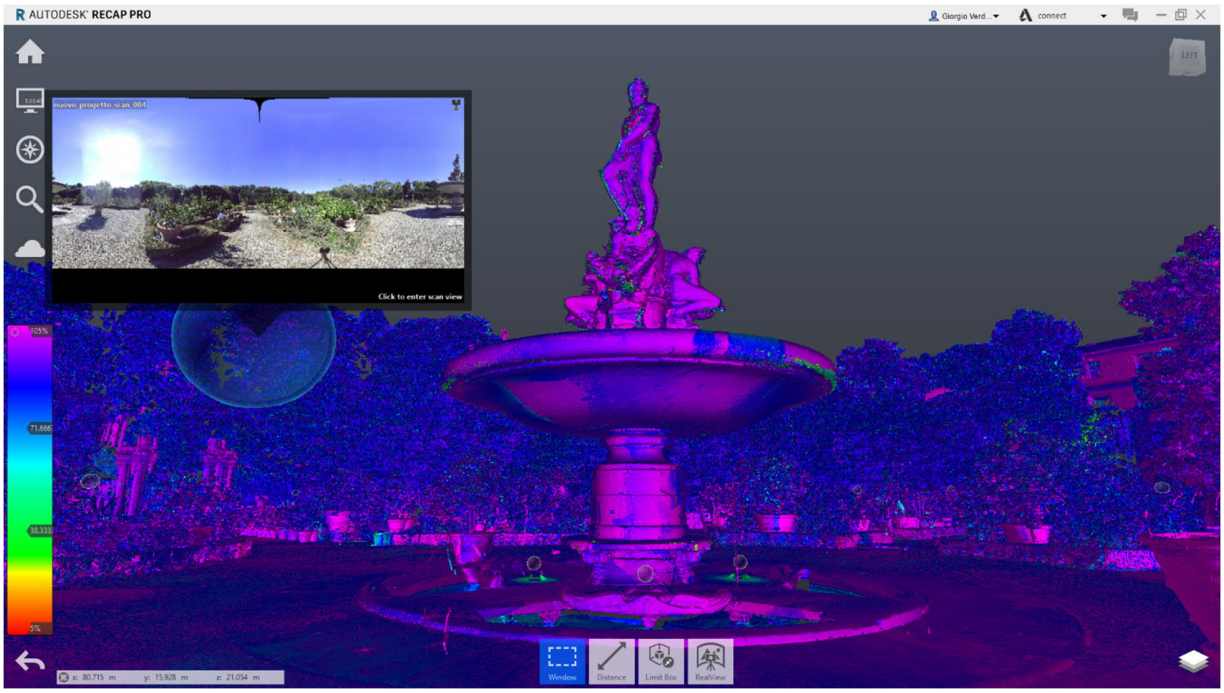


Fig. 11. View of the aligned point cloud (colours based on reflectance values)

The scanning resolution was set to “1/4” (the points are taken with a distance of 6mm at 10 meters of distance) for all the scan except for the four taken nearby the basement, taken with the resolution set at “1/5” (the points are taken with a distance of 8mm at 10 meters distance) and an accuracy with a 4x redundancy. The alignment was done using Autodesk Recap.

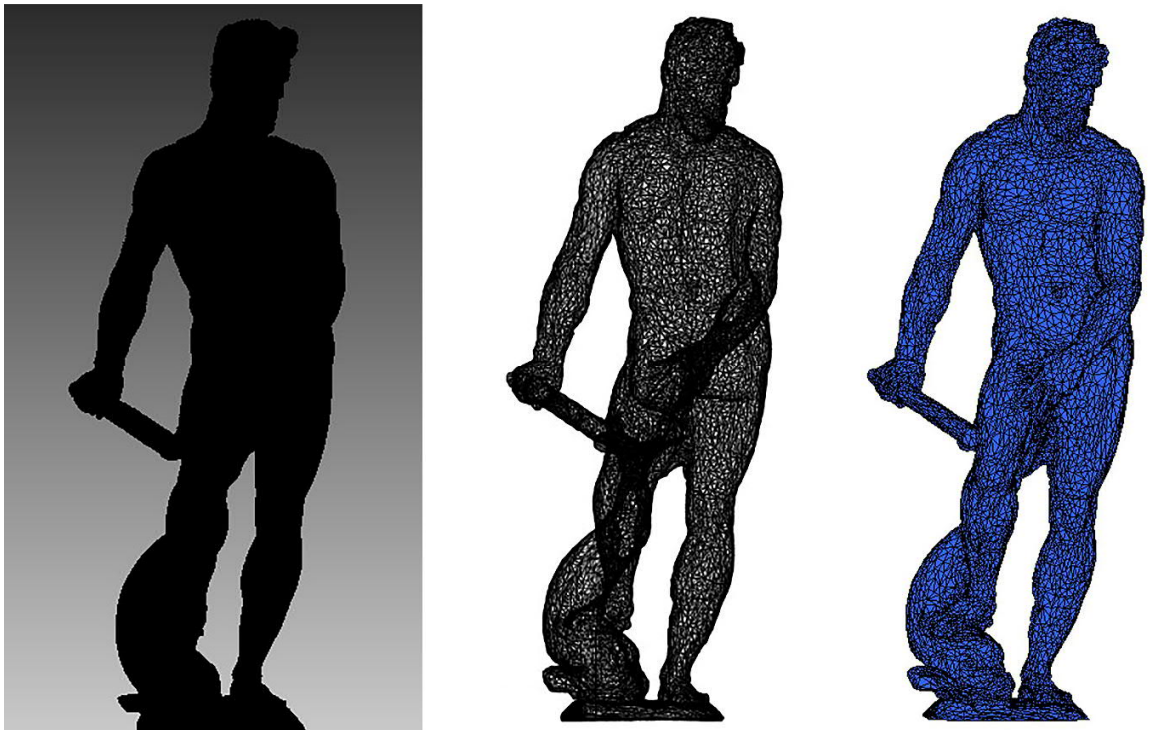
Fig. 12. View of the aligned point cloud (greyscale based on reflectance values)

MODELING AND SEISMIC ANALYSIS

The modeling and analysis part illustrated below refers to the original copy of Ocean statue preserved inside the Bargello National Museum. The same considerations and evaluations were made on the fountain in Boboli Garden.

Starting from the model obtained with the surveying instruments, the "finite element method" (FEM) model used for structural analysis was obtained by simplifying the initial model to make it suitable for a numerical analysis. At first step, the number of polygons was reduced through the *Quadratic Edge Collapse Decimation* procedure in *MeshLab software* [Cignoni et al. 2008], after which, it was implemented and transformed from a surface model into a volume model with *Strauss 7* (Fig. 13). According to simplified methodologies and approaches for the evaluation of the vulnerability of artistic artifacts [Liberatore et al. 2000; Ciampoli and Augusti 2000], a preliminary qualitative evaluation of the object was carried out. The case study belongs to a typological category *T3* (STAT-statue, sculpture and large vases), in particular A2 (object resting on a flat surface or pedestal), with consequent category of behavior A, specifically R4, or oscillatory response mode with overturning as a mechanism of associated damage.

The structural analysis was performed on a FEM model consisting of 125.600 four-nodes tetrahedral isoperimetric elements with the software Straus7. The sculpture is made in marble, with an Elastic Module of 50.000 MPa, a Poisson coefficient of 0,2 and a density equal to 2.700 kg/m³, while the pedestal is made in concrete, with an Elastic Module of 28.000 MPa, a Poisson coefficient of 0,2 and a density equal to 2.400 kg/m³. The statue and pedestal system were assumed as a single continuous body. At the lower face of the pedestal the X, Y and Z displacements were locked to simulate a joint at the base. This hypothesis allows us to evaluate the effects produced in the linear elastic field by seismic actions in terms of displacement and stress.



a b c

Fig. 13. FEM analysis on the 3D model of the Oceano's with differently simplified versions of the mesh: a) 2.000.000 triangular faces b) 23.200 triangular faces c) 103.300 solid tetrahedral elements

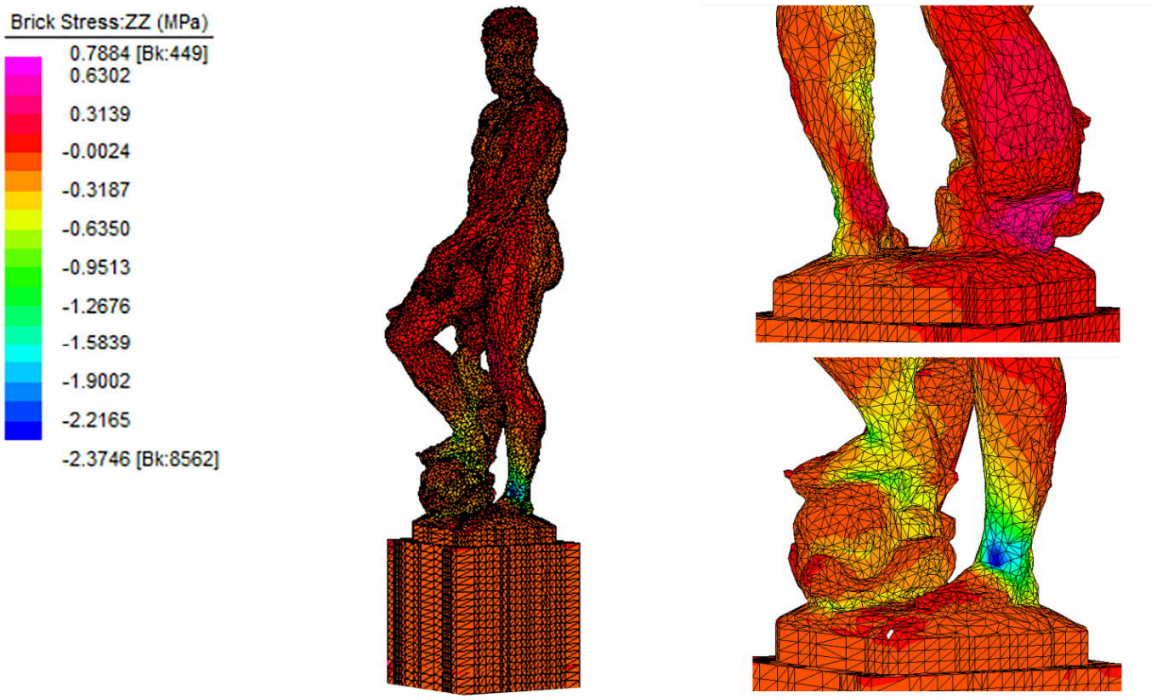


Fig. 14. Static analysis for vertical loads, views of the stress states ZZ

Fig. 14 shows the results provided by the analysis by considering only the proper weight as loading condition. In line with the position of the statue, there is a concentration of stress at the ankles, specifically, 2,3 MPa of compression in the front and 0,5 MPa of traction in the back. However, the compression and tensile values do not reach the resistance limits of the material.

A modal analysis has even been performed; it provided the natural frequencies of the main modes of vibration and it has been used also useful for quantifying the alpha and beta coefficients, according to the classical formulation proposed by Rayleigh [Chopra 1995] to be used in the dynamic analysis over time.

Figure 15 shows dynamic analysis performed in order to evaluate the possible response of the statue-pedestal as a single set. The seismic input was obtained through the Itaca [2008] from 7 accelerograms of real seismic events, compatible with the elastic spectrum proposed by the Italian code [NTC 2018] for the site of Florence, with a soil type B and a return period of 1950 years. The dynamic analysis provided results both in terms of displacement and of stress states. For all analysis, no significant displacements are ever achieved in the three main directions. The maximum value of stress achieved along the Z direction is equal to 3,7 MPa in case of traction and to 6,7 MPa in case of compression. The tensile stress value is very close to the assumed limit of the material.

Linear analyzes allow to highlight the areas in which the highest stress conditions are reached. In all analyzes carried out, it emerges that stress levels are concentrated in the area of the ankles. The obtained results allow a first evaluation of the elastic behavior of the statue; further modeling will be performed considering the non-linear behavior of the materials and inserting the effect of non-linearity produced by the pedestal statue contact surface.

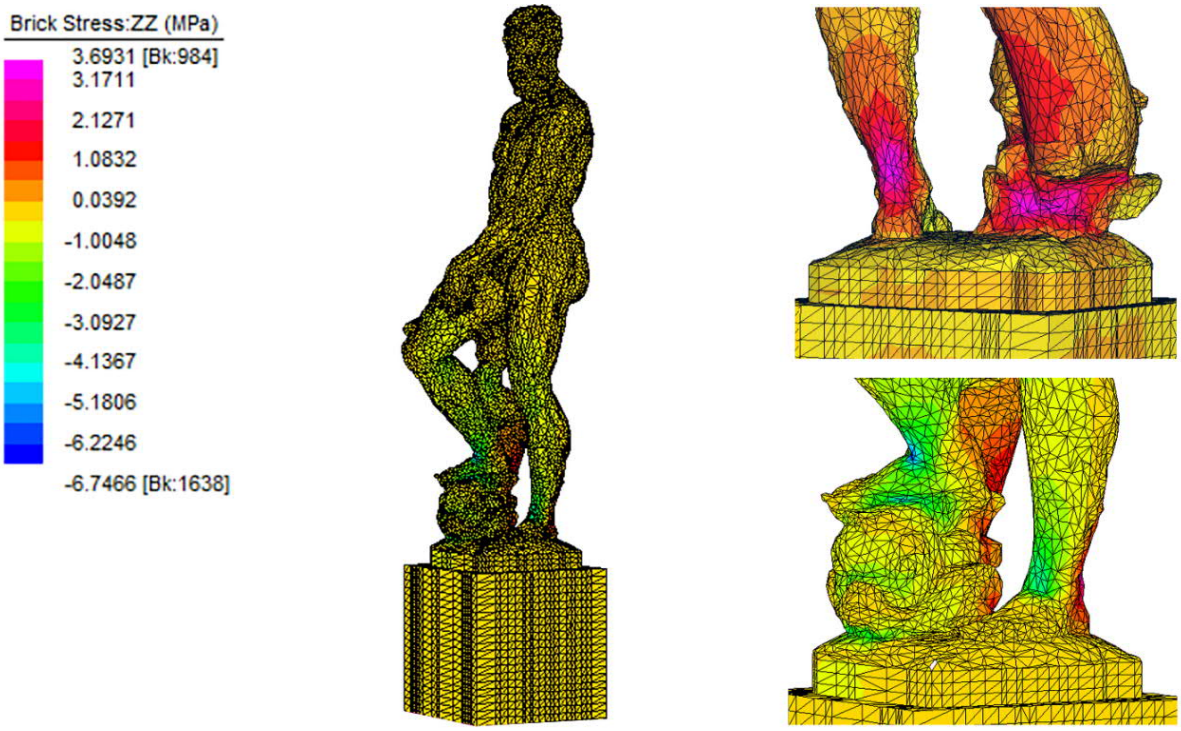


Fig. 15. Dynamic analysis, views of the stress states ZZ at 2,04 s for GMN earthquake

CONCLUSIONS

Italy hosts a great quantity of fundamental cultural heritage masterpieces; their protection from natural events and disasters plays an important role in the cultural and economic asset of the Country. The assessment of the seismic safety of art goods, such as marble statues, requires a complex series of procedures, which involve different research field. The quality of the geometrical representation of the objects is a required starting point for a reliable assessment.

The analysis performed on Nettuno/Oceano evidenced the importance of adopting the most recent technologies for performing the digital survey and to provide the geometrical data to use for analysis. An accurate polygonal mesh is at the base of advanced seismic analysis and, as shown in this paper, it can give clear indications about the weakness and the potential risk in the possible evolutions/events which can possible afflict the statue.

It should be noted that, even if in this work very professional tools have been used, similar analyses, despite less accurate and trustable in the results, could be performed by using mobile photography and cheaper cameras.

This “democracy” in the production of 3D models, if correctly exploited, may produce in the next years, a great resource for the analysis of our outstanding patrimony of statues and monuments.

ACKNOWLEDGEMENTS

The present research was developed starting from RESIMUS project and its previous developments, funded by the CRF Foundation, scientific coordinator Prof.ssa Stefania Viti. Special thanks go to the Photographic Laboratory of DIDALABS System (Dipartimento di Architettura, University of Florence) for the participation to the survey campaigns and the assistance during all the shooting and post-processing activities.

Fig. 16. The poster presented to CHNT Conference, November 2018

REFERENCES

M.S. Agbadian, S.F. Masri, R.L. Nigbor, and W.S.Ginell.1988. Seismic damage mitigation concept for art objects in museums. Proc. IX World Conference on Earthquake Engineering, Tokio-Kyoto, Japan.

BBCC. 2010. “Linee guida per la valutazione e la riduzione del rischio sismico del patrimonio culturale con riferimento alle NTC 2008”.

G. Cerri, G. Pirazzoli, G. Verdiani, M. Tanganelli, T. Rotunno, and S. Viti. 2017. Role of the new technologies on the artifacts seismic vulnerability, in Proceedings of CHNT22 conference, Vienna.

A.K. Chopra. 1995. Dynamics of Structures: Theory and Applications to Earthquake Engineering. Prentice-Hall, New Jersey.

M. Ciampoli and G. Augusti. 2000. Vulnerabilità sismica degli oggetti esibiti nei musei: Interventi per la sua riduzione. CNR – Gruppo Nazionale per la difesa dai terremoti. Roma.

P. Cignoni, M. Callieri, M. Corsini, M. Dellepiane, F. Ganovelli, and G. Ranzuglia . 2008. Meshlab: An Open-Source Mesh Processing Tool. In Sixth Eurographics Italian Chapter Conference, pp 129-136.

S. Gonizzi Barsanti and G. Guidi, 2017. A geometric processing workflow for transforming reality-based 3D models in volumetric meshes suitable for FEA, in The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W3, 3D Virtual Reconstruction and Visualization of Complex Architectures, 1-3 March 2017, Nafplio, Greece, DOI: 10.5194/isprs-archives-XLII-2-W3-331-2017.

S. Gonizzi Barsanti and G. Guidi, 2018, A New Methodology for Structural Analysis of 3D Digitized Cultural Heritage through FEA, in Florence Heri-Tech – The Future of Heritage Science and Technologies, IOP Conf. Series: Materials Science and Engineering 364, DOI: 10.1088/1757-899X/364/1/012005.

G. Guidi, L. Micoli, S. Gonizzi, M. Brennan, and B. Frischer. 2015. Image-based 3D capture of cultural heritage artifacts, in Proceedings of the Digital Heritage Conference 2015, Institute of Electrical and Electronics Engineers (IEEE).

Itaca. 2008. Database of the Italian strong motions data. http://itaca.mi.ingv.it

D. Liberatore, G. Spera, A. Claps, and A. Larotonda. 2000. Vulnerabilità dei beni archeologici e degli oggetti esibiti nei musei. CNR – Gruppo Nazionale per la difesa dai terremoti. Roma.

M.K. Lowry, B.J. Farrar, D. Armendariz, and J. Podany. 2007. Protecting Collections in the J. Paul Getty Museum from Earthquake Damage. WAAC Newsletter Volume 29 Number.

C. Mattoni and M. Tanganelli. 2018. Approcci semplificati per la determinazione della vulnerabilità sismica di opera d’arte: il Marzocco del Museo del Bargello, Firenze”. ReUSO, 2018.

L.M. Medri. 2003. Il giardino di Boboli. Silvana Editoriale, Milano.

NTC. 2018. Norme Tecniche per le Costruzioni. DM. Ministero delle Infrastrutture e Trasporti, 14 Gennaio 2008.

B. Paolozzi Strozzi. 2008. La storia del Bargello. 100 capolavori da scoprire. Silvana Editoriale, Milano.

B. Paolozzi Strozzi. 2014. Museo Nazionale del Bargello. Guida Ufficiale. Giunti Editore, Firenze.

B. Paolozzi Strozzi and D. Zykos. 2006. Giambologna: gli dei, gli eroi. Genesi e fortuna di uno stile europeo nella scultura. Giunti Editore, Firenze.

Parisi and Augenti. 2013. Earthquake damages to cultural heritage constructions and simplified assessment of artworks, in Engineering Failure Analysis 34 pp. 735-760.

F.M. Soldini. 1976. Il Reale Giardino di Boboli nella sua Pianta e nelle sue Statue. Multigrafica Editrice.

C.C. Spyrakos, C.A. Maniatakis, and I.M. Taflampas, 2017. Application of predictive models to assess failure of museum artifacts under seismic loads. Journal of Cultural Heritage 23, 11-21.

G. Verdiani, G. Pirazzoli, and G. Cerri. 2012. The Reconstruction of the “Fontana di Sala Grande”and some hypothesis about its original layout, in proceedings of the International Conference on Virtual Systems and Multimedia (VSMM) VSMM 2012 Virtual Systems in the Information Society 2 - 5 September, Milan, Italy, IEEE Institute of Electrical and Electronics Engineers, Inc.

S. Viti. 2018. RESIMUS. Un progetto rivolto alla vulnerabilità sismica delle opere museali.

C.E. Wittich, T.C. Hutchinson, R.L. Wood, M. Seracini, and F. Kuester. 2016. Characterization of Full-Scale, Human-Form, Culturally Important Statues: Case Study J. Comput. Civ.Eng.,30 (3).

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz

Museography and Performativity: Installing the Space-time of TAIRA's Eave

RODRIGO TISI PAREDES, Adolfo Ibáñez University, Chile

TAIRA's exhibition design not only presented stories of archaeological objects that are significant of the past, it also gave an account of the physical location in which this rock-art is located, at Loa's Valley River, in the north of Chile. The proposed design experience was meant to highlight all the discoveries on the research conducted for more than a decade. The exhibition, through a form of an immersive display, was developed with different specialists to look for different scopes; spaces of participation, spaces of reflection and experience as well as spaces of immersive technologies that somehow enhanced different dimensions to "construct" different moments of performance, in order to gain the spectator's attention who were visiting the museum. The main challenge was to "transport" the space-time of TAIRA's shelter to the exhibit space in Santiago, located at the Chilean Pre-Columbian Art Museum, and vice versa, at the same time, to transport visitors from the rooms of the museum to the spaces of TAIRA's eave in the valley of the Loa River. The exhibition considered a narrative script from three different approaches: ethnographic studies, site documentation and archeological objects. These combined approaches unfolded through the different rooms and permitted to build up the space-time of TAIRA's eave through the spaces of the museum. The data compiled in this exhibition was the result of several years of research done by a group of national and international researchers and professionals.

Key words:
Rock Art, Museum Exhibition, Audiovisual Display, Performance, Technology.

CHNT Reference:
Rodrigo Tisi et al. 2018. Museography and Performativity: Installing the Space-time of TAIRA's Eave.

INTRODUCTION

When the Chilean Museum of Pre-Columbian Art called to devise a way to present the rock art of TAIRA's eave (rock-shelter), the response was to create an immersive space, a temporal environment of experience and reflection, to highlight the location of this eave and its significant role to the local community that lives around the area.[1] The challenge was not only to present significant archaeological objects with their stories, but to give an account of the physical place, where it is located (Fig. 1). The objective was to present a memorable experience where this art, its landscape and its people meet. In a way, the challenge was to "move" the space-time of TAIRA's eave (Fig. 2), from the desert, to the spaces of the museum in Santiago. With this, the exhibition purpose was to transport the viewers, from the spaces of TAIRA´s eave located in the valley of the Loa River, to an immersive experience in the museum. The main challenge was to catch the attention of visitors by explaining ancient practices of the Likan-Antai culture. This rock art piece is somehow frozen, and it is a testimony, a ritual on earth´s reproduction, linking the deities that govern the earth and the sky.

Author's address: Rodrigo Tisi Paredes, DesignLab at the Design School, Adolfo Ibáñez University, Diagonal Las Torres 2640, Peñalolén, 7941169, Santiago, Chile. Emil: rodrigo.tisi@uai.cl

[1] The exhibition brought to light certain conditions of the place and the context in which TAIRA is located. It developed an immersive space that used audiovisual resources to provoke a moment of reflective experience, highlighting certain values, related to natural resources and animal reproduction. "TAIRA: el amanecer del Arte en Atacama" ("TAIRA: the dawn of art in Atacama") proposed a moment of enjoyment, of slow contemplation, similar to what can be perceived when someone is in such space-time where the rock-art is located. The space designed was meant to trigger a memorable experience for the visitors, and more than to become an object for cultural consumption (which could be found within the spaces of museums and tourism), the design was meant to commemorate rituals of local ancestral values.

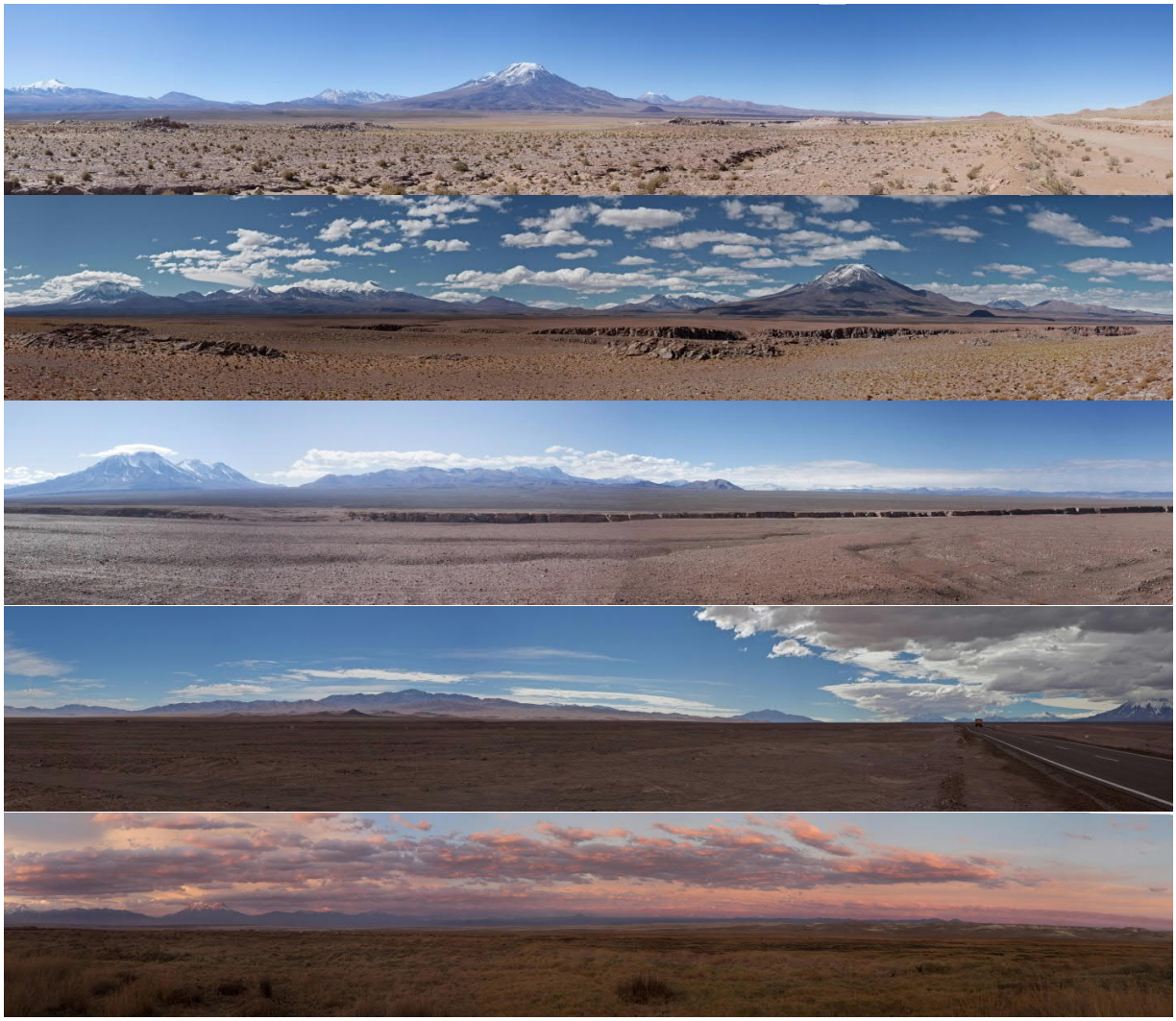


Fig. 1. Series of horizons, panoramic images of the Atacama Desert. Photo credits: Rodrigo Tisi, Simón Gallardo, and Eduardo Pérez

Fig. 2. Panoramic image of TAIRA's eave, a rock shelter on a hillside (rock-wall) of about 60 meters height. Photo credits: Rodrigo Tisi

Throughout the design process, different challenges were incorporated. On one hand, the exhibition was meant to do what is usually required on an exhibit of this nature; this is; to develop a concise narrative out of various objects organized along with historical texts and studies, to compose the script. Those were the archaeological contents that the exhibition was displaying to the visitors. This approach highlighted a rigorous scientific scope done through the research of many archeologists, among them, José Berenguer, chief curator at the museum in Santiago who was also the main curator of the exhibition. In Chile, his contribution has been recognized also because of the work done along with the local *atacameño* (ethnicity of South America that inhabited the interior of the Atacama Desert, also called Likan-Antai culture). Berenguer has been the author of several contributions about TAIRA´s eave.[2] This project demanded the incorporation of a series of ethnographic records that gave an account of the human and symbolic dimension of what is in TAIRA. This ethnographic dimension constituted a greater challenge as to devise the form on how to unfold the story through different spaces (steps on how and what should be displayed). The interviews conducted and the meticulous study of all the material of years of research lead to incorporate the use of different media; video and video mapping, sound, series of photographs and a 3D animation made with techniques of photogrammetry done by Diego Pinochet at the Design Lab UAI (Fig. 3).[3] The audiovisual media accomplished in the exhibition the intention to build a "realistic" experience, on "high definition", for the viewer's final perception. These resources improved the show and contributed to make the exhibit 'dynamic' and 'intriguing' as described by some visitors during the exhibition show.[4]

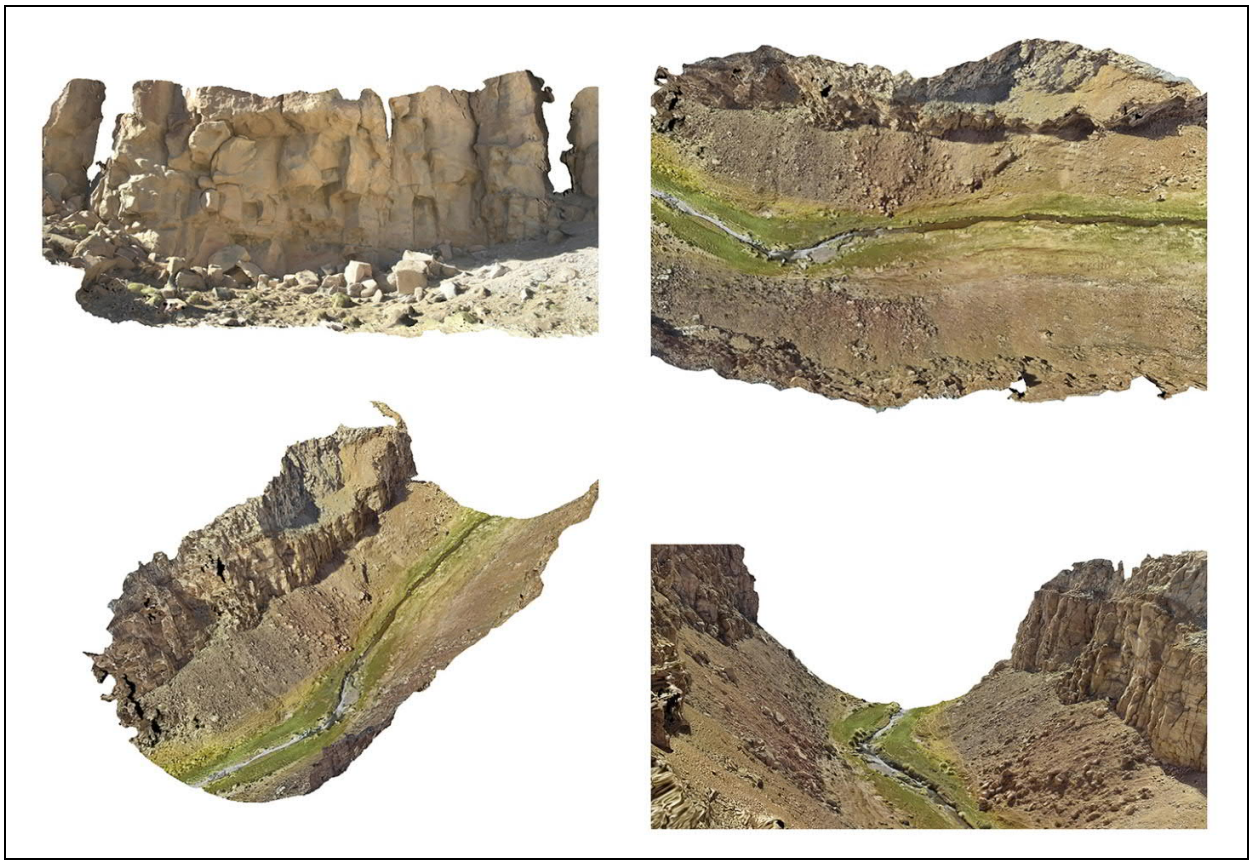


Fig. 3. Series of photogrammetric images: interactive 3D model displayed for the spectators on a touch screen. Image credits: Diego Pinochet, Design Lab, Universidad Adolfo Ibáñez

[2] For more information refer to "TAIRA: the dawn of Art in Atacama" (2017), a catalogue of the exhibition, in which José Berenguer expands ideas about heritage, landscape and rock art of the Atacama Desert, and north of Chile.
[3] Photogrammetry determines geometric characteristics of objects by using photography. The project used a drone camera to do an exhaustive survey of the hillside and the canyon of the Loa River. With these images the project was able to re-construct the topological characteristics of the site. This technology is highly accurate, and together with a special software, a very accurate model of TAIRA's eave was built for the spectators.
[4] The exhibition took place at the museum of Pre-Columbian Art between November 2017 and May 2018 and then from September 2018 to January 2019, at SFME in Antofagasta (sala Fundación Minera Escondida Antofagasta).

From the point of view of what was required to build this experience, the material aspects of the project, and the mechanisms used to communicate the content were key factors to consider throughout the whole design process [Hannah and Harslof 2008]. TAIRA was a construction journey in time and space, which in addition had the goal to invite people to "perform" a certain reflection. The idea was to provoke some kind of connection between the viewers (that are off site) with the site itself where TAIRA is. The exhibition generated awareness among other things about water issues that should be considered with the environment we all share (Figs. 4 and 5). In this sense, by combining technological resources (digital) with conventional materials (physical construction organizing the spaces of the exhibition), the project was able to "balance" content requirements to enhance communication transmission that the show had as a challenge. There were several iterations to decide as what should be the minimum amount of information and how this information should be told and displayed. With these decisions we had the opportunity to build "experiences", and therefore to transfer the issues and concerns described above (general public). The narrative was redefined several times throughout the process and in order to avoid overwhelming experiences, a lot of material was re-organized, simplified and edited, several times.

The exhibition spaces considered building panoramic as well as intimate places in order to situate the viewer in those unique conditions of the space-time of TAIRA. The museography liberated the storytelling structure to a much less linear development of the script. The navigation considered singular moments, some of them with 'surprises' that were not necessarily designed in a linear path, or only in one direction. In this way, the narrative was organized with texts and graphics in three levels:

1. Section title
2. First explanatory downgrade that described an explanation of what was presented
3. Second explanatory downgrade that described specific and technical details of what was presented.

The graphic panels were built by using "Medium Density Fibreboard" (MDF) processed wood and light cardboard cover that included a plastic layer finished with digital prints (heat sealed; thermo-layered film). These folded and re-folded panels were placed along the archaeological section to construct a series of corners and small eaves or "shelters" in the space of the exhibition. These spaces highlighted objects, diagrams, drawings and photographs (all of them as the result of the scientific research conducted by Berenguer et Martinez [1989]). The showcases built were literally observation niches, that on one hand solved the pause and contemplation required to understand each piece (as if the contemplation was performed on a similar topography of the existing place of TAIRA's rock art). In the other hand, they served to control de lighting issues of the exhibition (warm and cold LED lights were used). The material used for the niches (MDF processed wood and light cardboard) was very similar to the color of existing rocks, on the slopes of the Loa´s River Canyon. Each one of them served to exalt a scientific narration of the TAIRA period (Figs. 6 and 7).
The museography of TAIRA articulated different spaces and objects (or the representation of them) in order to complete "the trip" that the exhibition enabled. This was the main challenge of it, to find simple but eloquent ways to show the content of the rock art (Figs. 8 and 9). The organization of all those significant elements that were part of the display was fundamental to articulate the different moments of this symbolic transfer under the curatorial view.

With this, the occasion became an opportunity to explore different possibilities of expression, devising new forms of communication between what is exposed and the viewer (of different age range and diverse cultural origins). For this same reason, a universal audiovisual language was required. The standard technology used, along with communicational media, represented a unique opportunity to stimulate the senses of those who visited the exhibition. The idea was basically to let the viewer go home with a unique experience [Dernie 2006].[5] The challenges of this design considered multiple dimensions of the Likan-Antai territory and its culture, to capture moments of the Loa Valley, its immensity, its rocky slopes and the art engraved on the stones (in pictoglyphs and petroglyphs); an art about the sky, the land, the animals and the practices of the native peoples [Sinclaire and Martinez 2018].[6] With all this, the highlighted dimension design of the desert, its horizon, together with the

[5] See ideas of "experience" proposed by David Dernie in his Exhibition Design book. What stands out most is to explore new ways of approaching material and content, to see, and literally feel, the message. The strategy of 'experience' also tends to relate to the operations that are done to capture the attention of a less scholarly crowd.
[6] The curatorial contents of this exhibition are also presented on the third publication of ArtEncuentro, edited by Carole Sinclaire (2018), Chilean Museum of Pre-Columbian Art. For further information see references at the end of the text.

movement of its sky, suggests ideas of the past, present and future. This is a unique feature of the Atacama Desert, time seemed to be frozen. The challenge of the exhibition design had to combine dimmed ambiences to emphasize technological devices. Lighting details were fundamental to conceive the atmospheres of the interior spaces of the show (Figs. 10, 11, and 12).

Fig. 4. Series of images of TAIRA's rock-shelter (zoom-in of the eave). Photo credits: Rodrigo Tisi

Fig. 5. Main panel of the rock art of TAIRA's eave (detail). Photo credits: Rodrigo Tisi

Figs. 6 and 7. Niches built to display two sections of the exhibition: "People in the times of TAIRA" and "TAIRA under the magnifying glass". Photo credits: Pablo Blanco

Fig. 8. Rock art panel situation (first prototype) of TAIRA's eave. Photo credits: Rodrigo Tisi

Fig. 9. Rock art panel of TAIRA's eave with layers of research drawings. This layered drawings enabled the construction of the wall placed at the museum. Render credits: Eduardo Pérez

Fig. 10. Panorama 360° in section: Pachamama "Santa Tierra". Render Credits: Eduardo Pérez

Fig. 11. TAIRA's eave during the day (detail). Render credits: Eduardo Pérez

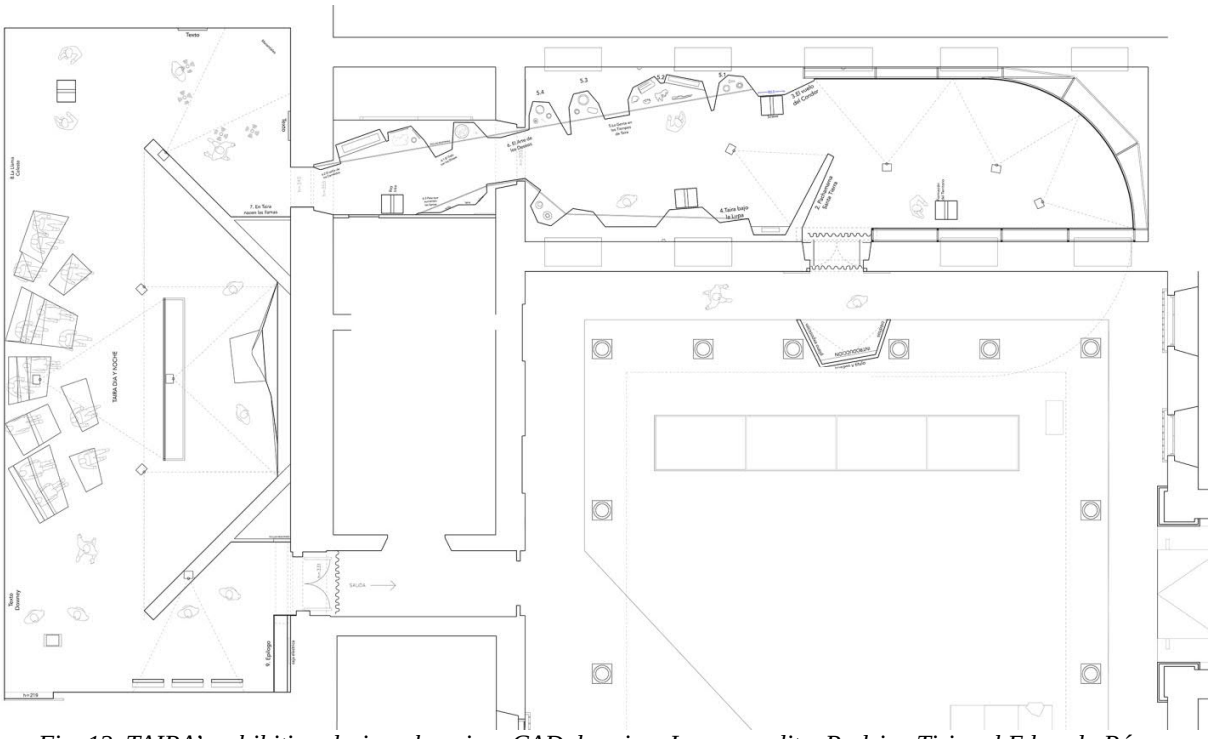


Fig. 12. TAIRA's exhibition design plan view, CAD drawing. Image credits: Rodrigo Tisi and Eduardo Pérez

But an exhibition could not only be just a form of presentation, and of representation. It could also be understood in more complex dimensions, with an open and active approach to interact with it, as a form *of* and *as* performance [Schechner 2002].[7] In this sense, the project not only dealt with the organization of elements and contents to 'act' with them, but also used certain communication and language resources of theatrical characteristics [Tisi 2008].[8] These situations lead the team to think of staging the moment of experience, by freezing it, while taking selfies for example. The exhibition allowed selfies as a mechanism of participation, a concrete "interaction" with the landscape of the desert described (Fig. 13). What is suggested here is that this form of exhibition plus the active participation of the viewer leads to different situations of performativity.[9] This explains the designed 'outcome' of all the elements that were 'in action'. The conscious design of all these characteristics constituted in itself an act of performance, since there was some implicit communication between the 'image' of the exhibition and the museum visitors. The readings obtained from what was installed are relevant not only to think and revise certain experiences, but also, to connect with what the show wanted to transmit. This performativity depends on the performed dialogues that the visitors enacted with the installation. That unique moment granted both by the space of exhibition along with the technological pieces that were built as part of it, along with the complementary TAIRA app, constitute the packet to embrace the 'trip' projected, which is neither in TAIRA nor in the museum.

Fig. 13. Visitor's selfie on panorama 360°, in section: Pachamama "Santa Tierra". The viewer freezes a moment "in the desert" while having an experience in the museum room in Santiago. Photo credits: Carole Sinclaire

The exhibition was developed in the following eight units:

"Pachamama Santa Tierra" which considered the idea of the panoramic landscape as the Holy Land. A series of 48 photographs were projected on a large format screen, showing the incommensurable landscapes of the desert. This space introduced the viewer into the desolate world of the desert and immediately transported it to the ground,

[7] Performance can be defined in the 'doing', in the 'present' and through the 're-presentation' of something on an effective manner. In Richard Schechner's introduction to performance studies, certain parameters are established, to describe when something is performance (doing something) or when something could be understood as 'performance' (when something re-presents something else). The author explains that something is performance when the audience (viewer) understands it and receives it as such, although it cannot define it. If the audience manages to understand it, that action, causes an effect. For Schechner, that outcome of the action, the effect can be understood *as* performance, then, that act, in fact, *is* performance.

[8] For architecture these elements are translated into materiality: light, program, time and anything that involves the physical configuration of a space, whether temporary or permanent. To expand further in these ideas see Tisi, R. *"B + S + P + T + PL + M:* Six Ways *to Approach Architecture through the Lens of Performance"* in JAE: Journal of Architecture Education 61, 4 (2008): 69-75.

[9] The definition of performativity has been explored in several disciplines, but mainly in the world of theater, anthropology and sociology. In his book "The presentation of the self in everyday life", Erwin Goffman talks about what is performative and how language plays a fundamental role in constructing temporary situations of performativity, which is nothing else than the effects of language and communication on people, often understood as decrees. One could say that the performativity of an exhibition is in the effects that such show produces, in the context where the work is located, and consequently, in the receiver eye/ear, the 'spectator' of the work. Certainly, there must be a cultural context that gives parameters to understand this performativity. Exhibition design needs to understand these parameters to actually design that effect.

its land, and the sky. To solve the design challenge, this space considered a perimeter that articulated a curved surface, a vision of about 270 degrees. Half of this amplitude is achieved by projecting an HD movie of about 10 minutes into a wall. The rest of the panorama is constructed with the reflection of the same image on a reflecting surface (black mirror in the opposite wall). This moment emulates the landscape of the place and puts the viewer in a visual state almost as if it were the desert environment [Sinclaire 2017]. The 'mirrored' surface in front of the perimeter projection of about 12.0 x 3.0 m high allows and creates the illusion of the horizon, of being in an open space. The eye can thus go through the details of the landscape that stands out (Fig. 14).

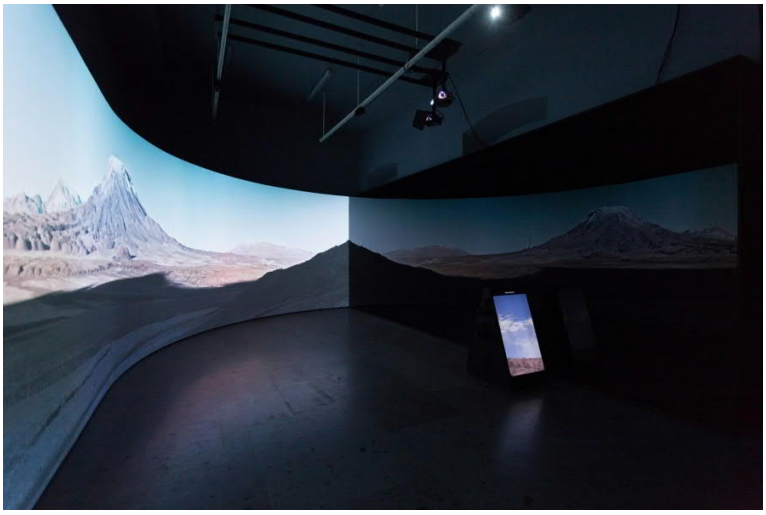


Fig. 14. 360° mirror assembly in section: Pachamama "Santa Tierra". Photo credits: Pablo Blanco

"The Cóndor's flight" presents the place from a bird's eye fly. This moment changed the point of view of the spectator and invited him/her to recognize the territory as if it were from the eye of a flying bird, in an HD movie of about 3.5 minutes. The position of TAIRA's eave was described with respect to geographical landmarks of the Loa Valley, such as the *Sirawe* hill, the river bed itself, the water springs, the scarce vegetation of its contour, the rocky configurations and the stones of the slope where the eave is. And as if it were a condor, the flight was sometimes very high and slow, and sometimes lower and faster (closer to the ground). A camera of a drone was used to find this point of view. Through the capture of multiple aerial shots and after a meticulous work of postproduction, the film manages to construct a narrative that presented the context of the eave from the sky, an impossible perspective for the human eye. Along with this aerial route, a representation of the TAIRA's eave, located on the slope of the Loa River Canyon, both in plan and in perspective/axonometry, was presented below the flight. This photogrammetric representation in 3D animation was achieved through an interactive screen that invited the viewer to navigate and explore the archeological site. The exhibition incorporated QR codes to download TAIRA's 3D app, allowing this representation of the eave to be taken as a souvenir.[10]

"TAIRA under the magnifying glass" and **"People in the times of TAIRA"** presented the most scientific moment of the exhibition, it took the viewer to the path of various archaeological researches made by a team which started around 1984. Through the contemplation of twenty-two archaeological objects, photographs of rock art, diagrams, analytical drawings and infographics, important aspects of the rock art of TAIRA and its archaeological context were explained. It described the techniques of painting and engraving used by the artisans that lived in the Atacama region during the time when this rock art was made. It ended with a timeline and a map of the region that related the style of TAIRA with other styles developed before -Kalina- and after -Milla- (Fig. 15). The museography of these sections was displayed in a corridor that simulated the Loa River Canyon (rock wall as on the hill side). At the same time, there were cases displayed which built a linear ethnographic story with different videos that told stories about the people that live there and its land. (Fig. 16).

[10] You can download the 3D version of TAIRA for Android or Iphone from the online app stores.
It can also be downloaded from the museum's website at: http://www.precolombino.cl/exposiciones/exposiciones-temporales/taira-el-amanecer-del-arte-en-atacama-2017/el-vuelo-del-condor/fotogrametria-del-alero-taira/

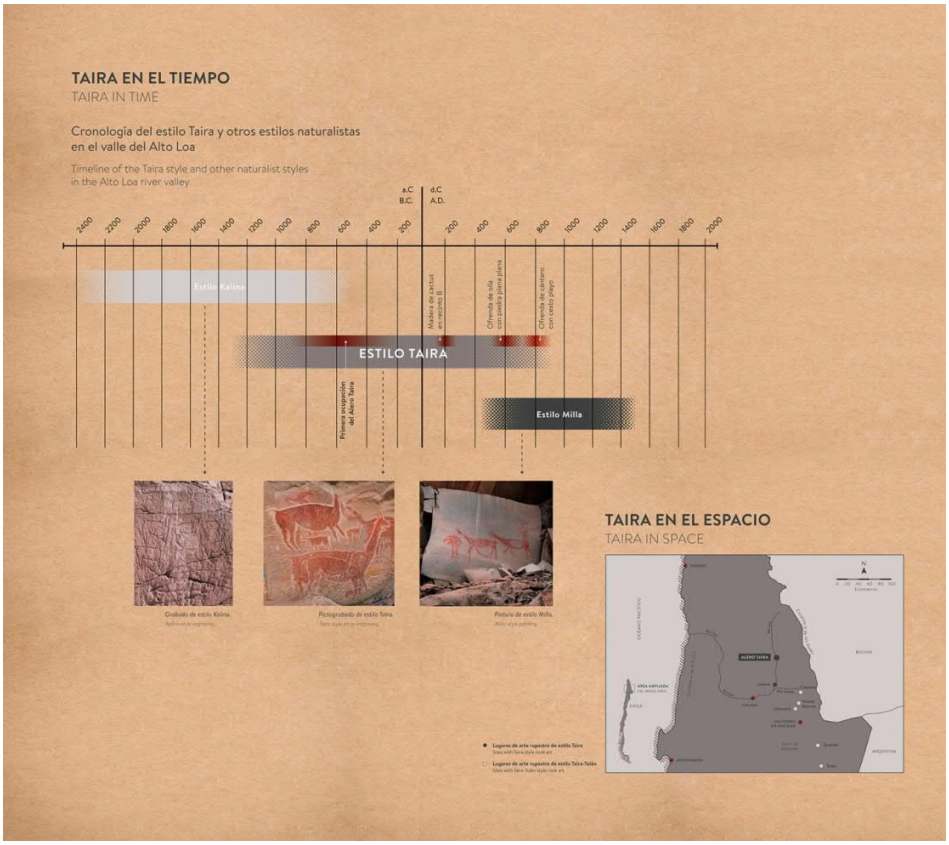


Fig: 15. "TAIRA in time" and "TAIRA in space". Diagram credits: Antonieta López

Fig. 16. Assemblies of units "TAIRA under the magnifying glass" and "People in times of TAIRA". In the background, the units "The condor's flight" and "Pachamama Santa Tierra". Photo credits: Pablo Blanco

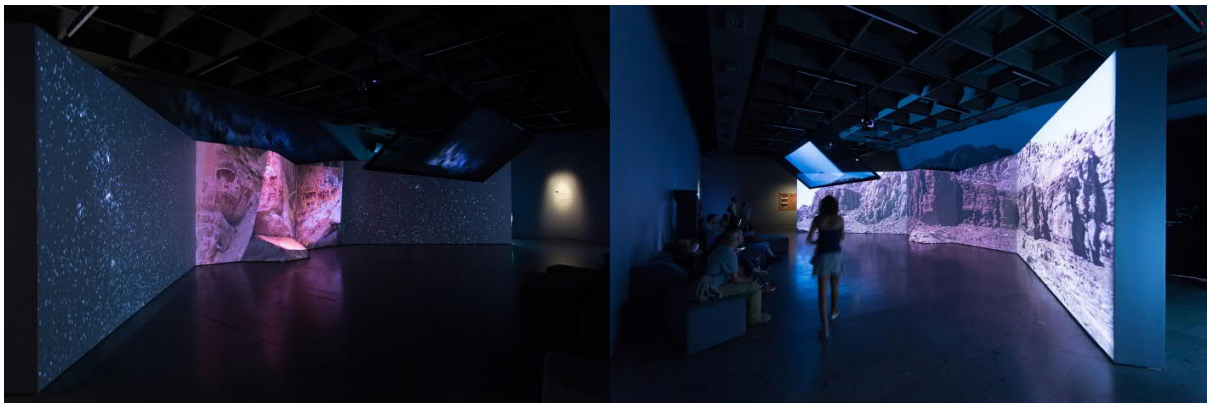
“The art of desires” showed the context that explained the role that the rock art of the TAIRA’s eave would have had. It organized a field of content that was linked to the relationship between heaven and earth. Here various cycles of life were described; they explained the importance of heaven and earth. This section highlighted a tradition of a territorial and celestial organization of earth and sky, which enabled fertility and reproduction. The exhibition in this part recalled symbolic elements and characters that intervene in the rites of art desires. Explanatory panels with texts, photographs and archaeological pieces installed, showed the cycles and systems of reproduction of the Llamas, and the beliefs that could exist in relation to the rock art that was represented at different times in the valley of the Loa River (natural reproduction and water importance).

“In TAIRA, Llamas are born” the beliefs and the connection of the animals with the earth and the spring are presented. This section highlighted how the Llamas reproduced and how certain configurations of the stellar universe were related to the place of TAIRA. This myth described and stimulated the cycles of life for native people. In here, the exhibition presented a projected corner of two planes of about 1.8 m x 3.6 m each side. Sometimes, both planes merge into a single continuous image which highlighted the horizon and the landscape of the place, and at other times, the projection was divided in two, making the center of both images coincide with the vertex of the room. This resource was used to present an ethnographic video in parallel to the landscape and the animals living there. This projection is complemented by a continuous audio, a description of the river made by a local farmer, Nicolás Aimani (Fig. 17).

Fig. 17. View of section “In TAIRA llamas are born”. This videa and the story told by Nicolás Aimani explain water importance and the Loa River’s stream. Photo credits: Pablo Blanco

“The Celestial Llama” described in a monumental way the dimension of the Loa Canyon, the river and TAIRA’s eave. The viewer encountered an 8-minute film that was installed on a triangular wall of about 3.0 m x 18.0 m, which simulated the existing rocky wall of the site (just like the side of the Loa River where TAIRA’s shelter is located). On this 'rock wall' a mapping projection was displayed to see in full detail the beautiful drawings of TAIRA done 2.500 years ago. This is one of the culminating and most powerful moments of the exhibition. Moments of day

and night were staged by means of a time-lapse projection. The same one alludes to the myth of the Celestial Llama that descends from the sky to connect with the Llamas represented in the drawings of TAIRA's the rock-art (Figs. 18 and 19).



Figs. 18 and 19. Unit assembly "The Celestial Flame": Photo credits: Pablo Blanco

The **"Epilogue"** presented, in a metaphorical way, the problems that TAIRA's eave is currently facing: one regarding the patrimonial value and the preservation of its art (tourism will soon arrive), and the other, regarding the native peoples that are descendants of the ancient Likan Antai inhabitants. Three full HD screens silently emit images of the landscape and the TAIRA people. On top of them the most significant words expressed in this exhibition (taken out of the ethnographic videos) were projected; they flow like a spring of words that construct the metaphor of noncommunication (Fig. 20). The water is crucial in the Atacama Desert and exploitation and climate change is putting this on risk. But just before the Epilogue, a quote of the architect and visual artist Juan Downey, who visited TAIRA in 1984, completes the show with a fragment of a video called "Information Withheld". This video is one of his early video works and was projected on a conventional 14" TV screen. Downey's eye on TAIRA's eave is fused then, with his vision about a contemporary world of consumption.

It can be said that in terms of performativity this exhibition was relevant not only to talk about education and the transmission of certain local concerns about resources. There is a need to preserve both tangible and intangible heritage. Perhaps the exhibition highlighted certain aspects that would make our own local culture more robust, by displaying the relevance to preserve our own backgrounds. The exhibition contributed not only to instruct those who visited it, but also to generate consciousness about the conditions and the "value" of our heritage in the north of the country. The exhibition was meant to transmit universal values beyond the spaces of the museum, to different audiences both in Chile and abroad.

CONCLUSIONS

As an academic that is interested in both theory and practice by means of design and design processes (as well as performance and performance studies methodologies), I can say that TAIRA served as an innovative mechanism to present and re-present content. Its display highlighted issues of heritage of local traditions and of cultural local scope that needed to be faced. The TAIRA exhibition, as a tool of communication, described concerns not only about rock art of 2.500 years ago but also about concerns that are around this zone, in relation to local communities, water and animal reproduction. The exhibition reached a great amount of people, more than 74.000 visitors in total, as explained by the communication specialist at the Pre-Colombian Art Museum.11 TAIRA is a contribution towards innovation in research as it can be considered as a "research product" of high impact that not only reached experts of different disciplines and academic backgrounds but also, and most importantly, cause awareness on regular people (diverse groups: from kids, to students, to adults to old people). The exhibition served as a tool to teach and

[11] TAIRA was very successful to bring and important amount of people to the museum spaces (in its three versions). In Santiago the exhibition space received 71.401 visitors, in Sala Fundación Minera Escondida in Antofagasta received 2.508 visitors and, in exhibition space of San Pedro de Atacama, it received 790 visitors.

highlight certain values that are still there, left, to preserve the traditions and beliefs of a community and its heritage. After its success (exhibition presented in the late 2017, during 2018 and early 2019), the local community of TAIRA is doing efforts to try to bring the exhibition to a permanent display. With this same aim, to extends its life, the Pre-Colombian Art Museum has demonstrated interest to try to tour TAIRA to reach an international audience.

Fig. 20. Assembly of the "Epilogue" unit. Photo credits: Pablo Blanco

REFERENCES

José Berenguer and José Luis Martinez. 1989. "Camelids in the Andes: rock art, environment and myths" in Animals into Art, H. Morphy Ed., Unwin Hyman/One World Archaeology, London (1989): 390-416.

David Dernie. 2006. Exhibition Design. London: Laurence King Publishing, 192 p.

Ervin Goffman. 1956. The presentation of the self in everyday life. New York: Random House, 251 p.

Dorita Hannah and Olav Harslof eds. 2008. Performance Design. Copenhagen: Museum Tusculanum Press, University of Copenhagen, 336 p.

Richard Schechner. 2002. Performance Studies an Introduction. London and New York: Routdledge, 288 p.

Carole Sinclaire (Ed.). 2017. TAIRA, the dawn of art in Atacama. Museo Chileno de Arte Precolombino. Santiago: Ograma, 120 p.

Carole Sinclaire and Paula Martinez (Eds.). 2018. "La exposición de arte rupestre de TAIRA tras bambalinas: seis ensayos y un guion" in ArteEncuentro #3 Museo Chileno de Arte Precolombino. Santiago, 206 p.

Rodrigo Tisi. 2008. "B + S + P + T + PL + M: Six Ways to Approach Architecture through the Lens of Performance" In JAE: Journal of Architecture Education 61, 4 (2008): 69-75.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz
The editor's office is not responsible for the linguistic correctness of the manuscripts.
Authors are responsible for the contents and copyrights of the illustrations/photographs.

An Innovative Approach towards Preservation of Tangible Cultural Heritage Issues through the Lens of the Public Relations

NINA TOLEVA-NOWAK, University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria
WIKTOR NOWAK, Academy of Music, Dance and Fine Arts – Plovdiv, Bulgaria, Plovdiv, Bulgaria

The preservation of cultural heritage has a long history and a vast theoretical background. Yet its current issues are more challenging and some of its contemporary approaches – more controversial. The biggest risk factors for the tangible heritage are war-related destruction, damage done by the intensified cultural tourism, demolition and inadequate treatment due to urban sprawl and infrastructural development, owners' reluctance to take proper and sufficient care for the monuments due to heavy administrative procedures, inconsistent laws and regulations coupled with high costs for maintenance and renovation.

These problems have a common denominator – the inability of the public and the stakeholders to recognize the importance of the tangible heritage as an external common memory, as a valuable testimony and material proof for past events. By analysing the current issues and the top-down nature of the legislation (both national and international) and the fact that most of the preservation actors and procedures are highly institutionalised, we believe this inability is rooted in the lack of available and sufficient public information about monuments under threat, especially those of local importance.

Thus we propose an innovative communication-based bottom-up preservation approach which would popularise architectural heritage with the methods of public relations and the tools of crisis communication. By addressing issues on the professional and nonprofessional level, by small personal interventions, by visualising the loss of the heritage fabric on local and national level we strive for raising an open and honest discussion about the future of built heritage as an irreplaceable bearer of information. We aim to raise awareness of the importance of everyday preservation, to educate a broader and more informed audience, to foster a higher sensitivity towards public memory issues, in order to pass our history and our memories to future generations.

Key words:
Bulgaria, heritage, public relations, management, preservation, bottom-up.

CHNT Reference:
Nina Toleva-Nowak and Wiktor Nowak. 2018. An Innovative Approach towards Preservation of Tangible Cultural Heritage Issues through the Lens of the Public Relations.

INTRODUCTION

The concept of cultural heritage has a long history and vast theoretical background interlinked with the development of the urban fabric. During the past century the protection of cultural heritage has seen a worldwide increase in the establishment of a legal framework encompassing charters, recommendations, guidelines and conventions (Fig. 1).

Author's address: Nina Toleva-Nowak, Department of "History and Theory of Architecture", University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria; email: ntoleva@gmail.com; Wiktor Nowak, Department of "Applied Arts", Academy of Music, Dance and Fine Arts, Plovdiv, Bulgaria, email: vik.nowak@gmail.com

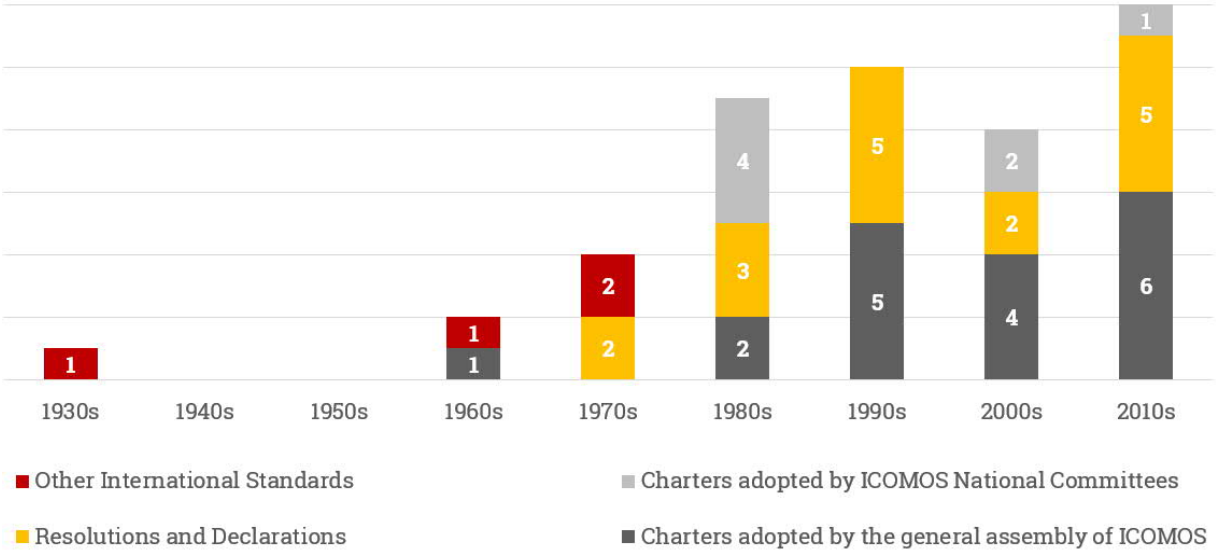


Fig. 1. Charters and other doctrinal texts developed or accepted by ICOMO[1]*, © N. Toleva-Nowak & W. Nowak*

The biggest risks to the architectural heritage are war-related destruction [Stig Sørensen and Viejo Rose 2015], damages by intensified cultural tourism [Harrison 1994], air-pollution [Watt 2009], natural disasters [Meier et al. 2007], demolition of ruined monuments and/or their inadequate treatment, abandonment and intentional or unintentional structural collapse; accelerated urban/infrastructure sprawl and development [Agapiou et al. 2015] and urban quarters renovations, leading to the demolition of cultural heritage as it is often perceived as an obstacle to urban development. The common denominator for all these issues is the owners' inability or even reluctance to take suitable care for the monuments leading to their fast and irreversible physical deterioration and turning them into a hazard for the inhabitants and the public. Last, but not least, a huge setback for the proper preservation are the inconsistent laws and regulations, the long and heavy administrative procedures during the development of restoration and conservation projects, the specifics and the high costs for the urgent building fortification and consolidation works and renovation actions.

THEORETICAL FRAMEWORK

The first broad public issues marking the beginning of the fight for the preservation of architectural cultural heritage was the attempt by Robert Redhead to demolish Clifford's Tower in York (UK) in 1596, which led to intense citizen protests [Cooper 1911]. Later the debate stirred around Viollet le Duc's and John Ruskin's [Ruskin 2013]contrasting concepts on preservation [Spurr 2012]. Three decades later William Morris proposed that a delicate balance in preservation based on daily care and minimum drastic interventions is needed in order to counteract the growing loss of authenticity [Morris 1877].

Morris' daily care proposal ensuring the survival of a building is reminiscent of the homeostasis and processes needed to keep an organism alive. The metaphor of the city as a living organism and the good maintenance practices are among the leading topics in the works of Plato (Timaeus), Aristotle (The Politics) and Vitruvius (De Architectura). Regarding the city as a living organism and contemplating the needs for its well-being, in the Medieval Ages, the work of Francesco di Giorgio Martini further develops the concept by representing not only the city as a whole, but also the individual building as a complex organism.

The biological metaphor may be the key to the "Theseus' ship paradox" in regard to cultural heritage preservation – a living organism changes its constituent cells many times over its lifetime, but the value lays in the functioning collection of parts and the complexity of the whole. The care-and-repair process is just as important as the structural

[1] data from https://www.icomos.org/en/charters-and-other-doctrinal-texts

and aesthetic integrity, and thus both the skills and the know-how for proper maintenance of a building constitute a vital part of its tangible and intangible value.

The bio-metaphor is particularly suitable when it comes to the built cultural heritage, due to the long and multi-layered evolution of the edifices. The longevity and the well-being of the monuments could be addressed similarly to the well-being of an individual by adapting Maslow's Pyramid of needs [Maslow 1943] – a classification system describing the universal individual and societal needs. By transcribing this social concept in the field of the architectural heritage, sustainable preservation and environmental practices could be achieved:

Table 1. Maslow's pyramid transcribing to the tangible heritage needs

	№	Maslow's pyramid of needs	Scope	Heritage's pyramid of needs	Achieved level of preservation
Basic needs	1.	Physiological needs: 1.1) Breathing; 1.2) Food; 1.3) Water; 1.4) Shelter; 1.5) Clothing; 1.6.)Sleep.	Basic/physiological needs for the survival of the subject.	Physical needs: daily, weekly, annual maintenance practices, inspections, cleaning, etc.	Ensuring the physical survival and structural integrity of the monument
	2.	Safety and security: 2.1) Health; 2.2) Employment 2.3) Property; 2.4) Family and social stability.	Safety needs	Safety needs: small repairs and renovations, ensuring the safety of the building, its proper condition	
Psychological needs	3.	Love and belonging: 3.1) Friendship; 3.2) Family; 3.3) Intimacy; 3.4) Sense of connection.	Social belonging and communal belonging: proper integration in the existing society	Conservation and restoration: accentuating the most valuable and most specific function and appearance of the monument in terms of its history and evolution	Securing the historical value authenticity – a valuable prerequisite for social importance and longevity of the monument
	4.	Self-esteem: 4.1) Confidence; 4.2.) Achievement; 4.3) Respect of others; 4.4) The need to be a unique individual 4.5) Meeting the ego needs	Esteem – proper development within the existing society and culture, feelings of accomplishment	Societal adaptation: achieving proper inclusion and function in contemporary life. Utilising the monument in its full potential in order for it to be useful for the community; to gain recognition and to keep the building alive	
Self-fulfillment needs	5.	Self-actualization: 5.1) Morality; 5.2) Creativity; 5.3) Spontaneity and acceptance; 5.4) Experience purpose;	Reaching the full potential of the individual/the monument in order to reach sustainable and fulfilling existence.	Sustainable preservation: reaching the full potential of the building and its role in contemporary urban life, which ensures its proper place, care and longevity.	Reaching sustainable preservation and ensuring the longevity and well-being of the monument

Following the Table above, the sustainable preservation, exploiting and exhibiting the full potential of the heritage cannot be achieved without satisfying the basic safety needs. The common denominator of most of the problems at the basic level in the process of the initial physical preservation of the heritage is rooted in the inability of the owners, the inhabitants and the stakeholders to understand the significance of the monument and its four major value aspects [McCaig 2013a]: evidential, historic, aesthetic, communal.

Thus, in the best interest of the users, owners and the community is bringing closer the heritage and the broad public. This principle of aligning mutual interests is the keystone in the practice of Public relations, and involves several tools like raising awareness, spreading easily assimilated information, involving the local community. By empowering the stakeholders, by giving them knowledge and proper tools to tackle the daily maintenance problems and to take suitable care of the monument by themselves, the first and most important steps towards sustainable preservation are being made.

AIM AND METHODOLOGY

The common denominator of most problems facing cultural heritage is the inability of the broad public and stakeholders to recognize the value of the built heritage as a precious material proof for past events, as a community

binder, as an element bringing aesthetics, vitality and diversity to the urban environment, enriching the spirit of the city, and creating versatile space and multi-layered environment. In order to tackle this, the authors propose an innovative communication-based bottom-up preservation approach for raising awareness among the broad public which has no understanding of the concept of preservation, engaging PR's methods of crisis communication. The methodology includes: problem analysis and assessment of the current architectural heritage issues in Bulgaria, creating a suitable communication strategy, elaborating monitoring parameters for the results and planning future steps. (Fig. 2)

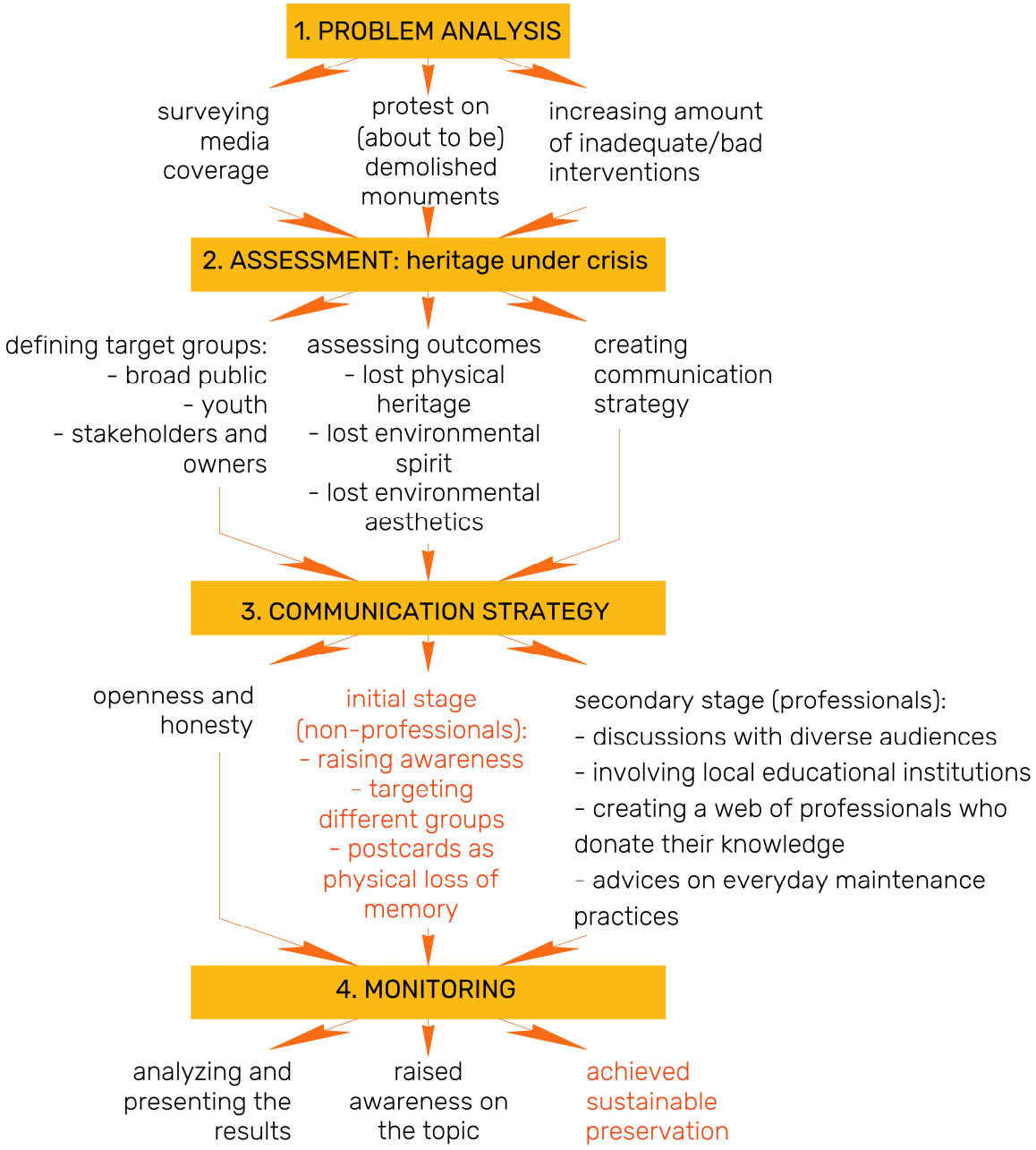


Fig. 2. Methodology, © N. Toleva-Nowak & W. Nowak

PROBLEM ANALYSIS

Bulgaria has a diverse and rich cultural heritage with its 39,476 listed monuments of culture (Figs. 3a and 3b) according to Functional Analysis of Sectoral Policy in the Field of Protection and Presentation of the Immovable Cultural Heritage, implemented as a part of BG05SFOP001-2.001-0006 project „ Establishment of uniform rules for carrying out functional analyses of horizontal and sectoral policies “, financed by ESF “Good Governance”.

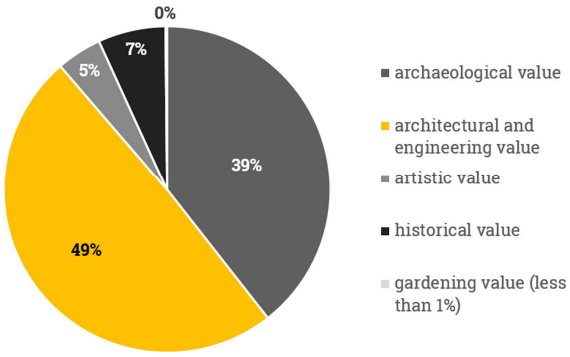


Fig. 3a. Types of listed monuments, © N. Toleva-Nowak & W. Nowak

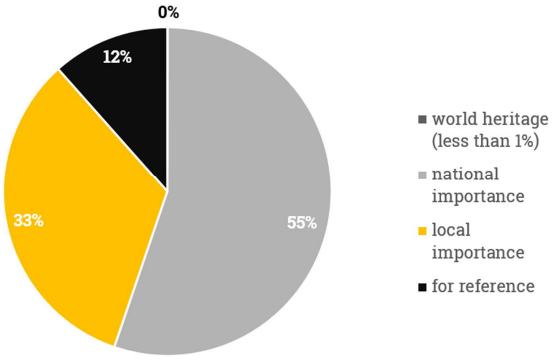


Fig. 3a. Listed monuments in terms of their value, © N. Toleva-Nowak & W. Nowak

Bulgaria has over 140 years of history of preservation of cultural heritage and the topic of preservation and care for the national cultural and historical heritage are enshrined in the Constitution (Article 23). It also states that everyone has the right to enjoy national and universal cultural values (Article 54). Overall, the process of preservation on a state level can be divided in 4 main periods. Svetoslav Georgiev suggests it may be divided into three main periods [Georgiev 2008], yet with Bulgaria joining the EU in 2007 and the resulting harmonization of the legislation, a fourth one is needed.

The first period encompasses the years from the Liberation (1878) up to the “World War II” (WWII) and relates to the first laws and regulations on cultural heritage management (Provisional rules for scientific and literary enterprises 1888, Law on the Search for Antiquities and for the Support of Scientific and Literary Enterprises 1890, Antiquities Act 1911, Ordinance-law for the preservation of ancient buildings in settlements 1936). They protect historical richness in their diversity (both tangible and intangible) and set the boundaries of the institutional system for preservation.

The second period starts after the end of WWII and lasts up to 1990 with the fall of the Socialist regime. During that period all the regulations and institutions are dismissed and a new structure takes place – The National Institute for Monuments of Culture (1957), which covers all cultural preservation and management policies and practices.

The third period (1990-2008) is characterized by the decentralization of the rights and the responsibilities and involvement of different actors in the conservation process – other state, municipal structures, institutions and public actors, designers, etc.

The fourth period (after 2009) after the EU accession and the harmonization of legislation, the Law on Cultural Monuments and Museums (1967) is repealed and the Law on Cultural Heritage (2009) enters into force, which currently has 12 amendments (Fig. 4).

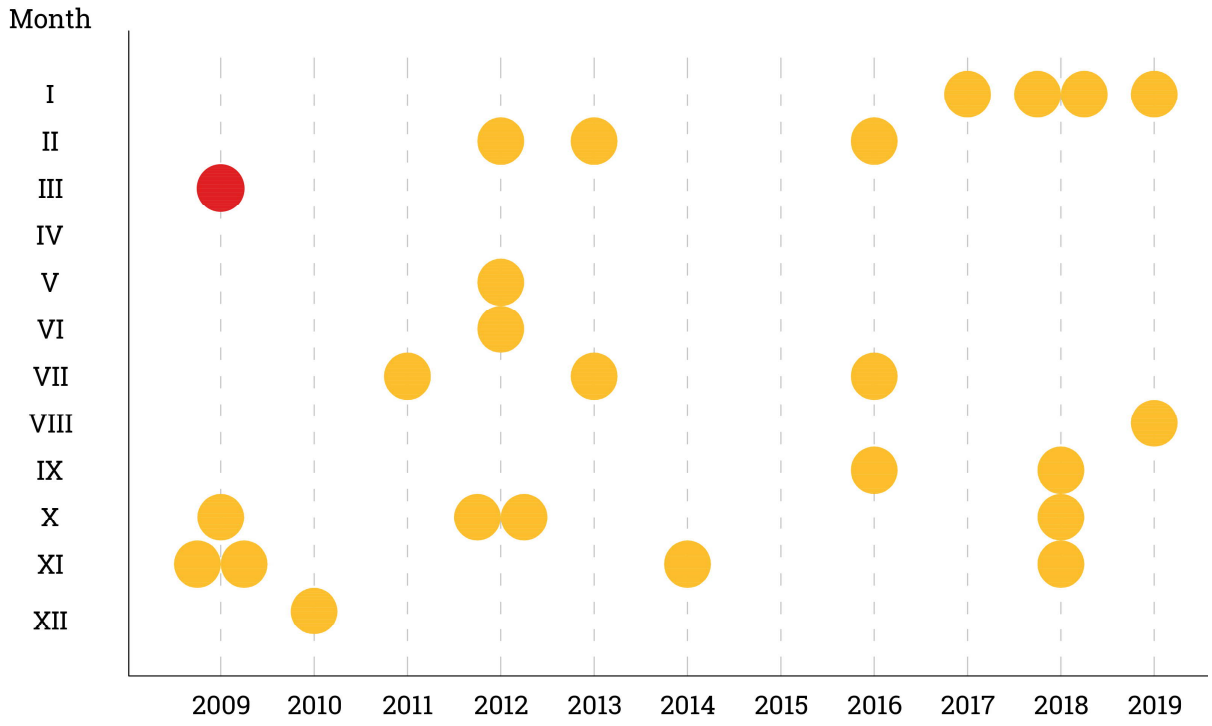


Fig. 4. Changes in the Law on Cultural Heritage from its publishing up to August 2019,
© N. Toleva-Nowak & W. Nowak

According to an audit report on the implementation of the "Conservation and Maintenance of Architectural Heritage Sites in the Urban Environment for the Period 01.01.2015 to 30.06.2018. " from February 2019, the identified problems are mainly related to the impaired coordination between the conservation bodies, the lack of sufficient administrative capacity, gaps in the existing rules as well as a number of laws on the protection of cultural heritage that are based on or cite non-existing, phantom regulations. It is worth noting that the report itself is also top-down and does not allow for the involvement of non-institutional partners. Unfortunately, in the final recommendations to this report, the burden of conservation efforts is once again placed on the state or municipal structures, while also reinforcing restrictive measures on other stakeholders.

At the regional level, there is a section on cultural heritage in the regional development plans, but it is broad and quantitative in nature, only listing the number and type of objects, with no comments on the property ownership structure and no in-depth analysis of their condition and problems affecting conservation measures. In 3 out of 265 municipalities in Bulgaria (Sofia, Plovdiv, Gabrovo) that have developed a cultural strategy (Dobreva, N., 2018. Стратегии за развитие на културата като възможност за българските общини. Известия на Съюза на учените - Варна. Серия Икономически науки , 7(1), pp.145-153.) there is again only broad quantative data on immovable cultural heritage. There is no focus on the problems, strategies and opportunities for adequate protection and promotion and the involvement of owners and other interested parties.

According to Miroslav Krastev this top-down centralization and institutionalization of the decision-making process leads to disassociation between the stakeholders and the broad public and the heritage itself, and fortifies the perception that the State is the only actor in the process of preservation [Krastev 2016]. He also suggests incorporating the concept of "participatory governance" in the management process, which is a leading topic in the European Agenda for Culture: Work Plan for Culture 2015-2018 [Krastev 2015; Kabakov 2018]. Yet this principle implies a strong knowledge and understanding about the basic values and principles of the cultural heritage. Overall, there is a striking lack of studies, surveys and attempts on the bottom-up approach towards preservation of cultural heritage in Bulgaria.

In order to trace the understanding and the involvement of the broad public in Bulgaria with the problems of the cultural heritage, a survey in the online media coverage was implemented. The survey included covering news about

monuments demolished by fire, arson, negligence, bad interventions or conscious demolition in favour of new modern buildings, lawsuits about ownership, controversial decisions about the value of the monument, discussions and protests on the future of archaeological remnants and other listed buildings and monuments, public discussions and presentations on key projects concerning cultural heritage, as well as protests against the demolition or impending demolition of listed buildings.

The first online articles dated back to 2003 with news for a listed building demolished in a fire. As seen in Fig. 5, the trend of buildings demolished or severely damaged in a fire is increasing, reaching its peak in 2016. Another worrying trend is the number of demolished or self-collapsed buildings and its peak almost doubling in 2017. On the other hand, the reaction of the public (mainly specialists and people with acute interest in the field of cultural heritage) increased after the intensification of those trends, which leads to the conclusion that an even broader information campaign on the significance of the cultural heritage and its understanding is needed. Also, these news mostly reflect the problems with the listed buildings of national importance. For the monuments with lower protection, there is hardly any news coverage, rendering the following graph as just the tip of the iceberg:

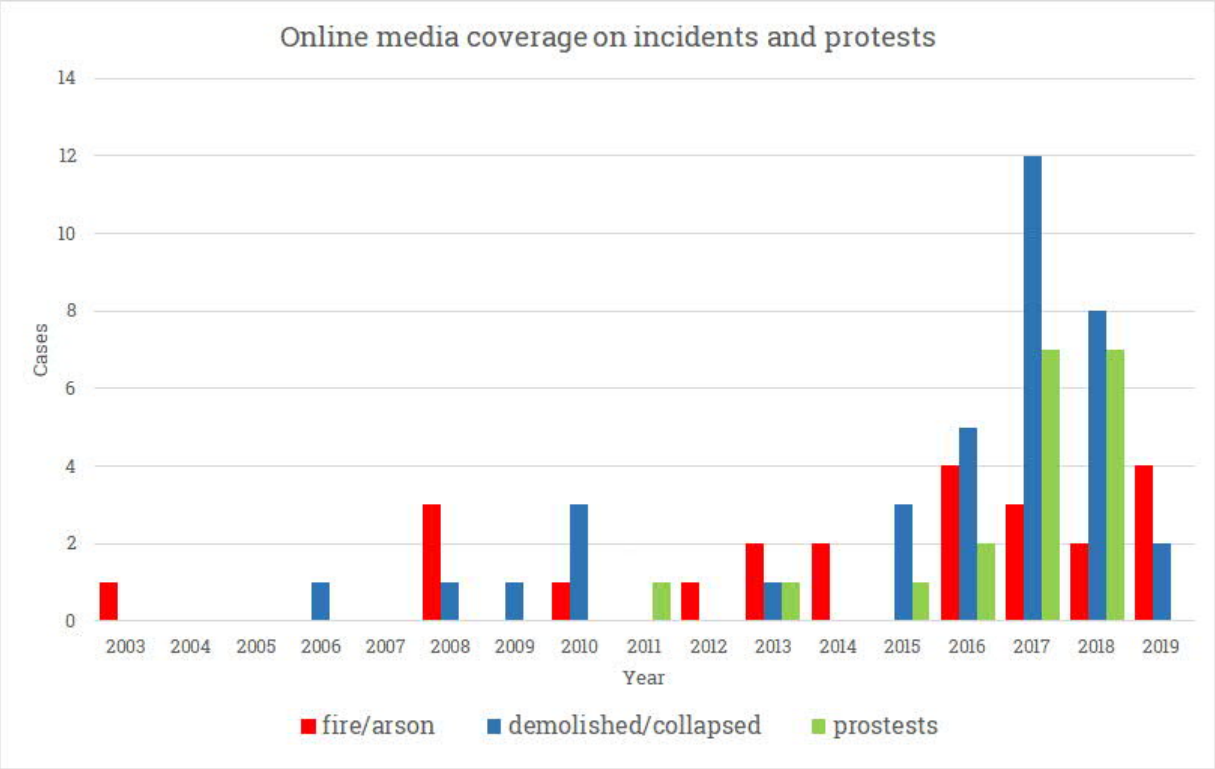


Fig. 5. Online media coverage of incidents or protests and discussions on cultural heritage demolitions and collapses (up to February 2019), © N. Toleva-Nowak & W. Nowak

Another major factor is that most of the listed buildings are privately owned, and a huge percent of them have a shared ownership among more than 10 owners, which hampers the decision process for any repair or restoration even further.

Also, the heavy, expensive and complex administrative procedures often push the owners towards conscious negligence, leaving the monument to decay beyond repair or even collapse, in order to create a *tabula rasa* for new investments and to substitute the monument with a new building, mimicking (often unsuccessfully) the original one. A common practice is to leave the roof damaged (or damage it on purpose) and wait for a few winters for the wood to rot and collapse and thus to be rendered dangerous for the community and up for demolition.

These factors, along with the increasing amount of inadequate or bad interventions in the cultural fabric due to private initiatives (inadequate measures for energy efficiency, false reconstruction and improper add-ons onto

existing buildings, unsuccessful restorations with poor quality, etc.) that were observed during field surveys has led to the final assessment that the cultural heritage in Bulgaria is in a state of crisis (Fig. 6).

Fig. 6. Monument in decay, © N. Toleva-Nowak

In conclusion, various legislations, including much of the international charters and instruments, have a strong top-down character. By this forced institutionalization of the value of the monument, by taking a leading part in every initiative and by the highly restrictive nature of the laws and regulation, the main burden and responsibility for the preservation of the monument is transferred to the owner, without any financial or other form of support from the state. This is especially problematic for monuments of local importance (representing 45 % of all monuments in Bulgaria) because they are mostly private property, predominantly in desirable locations. The hard economic situation and a series of economic crises have a direct impact on the state of the architectural heritage. As a result, even petitions are being drawn up to remove a UNESCO World Heritage Site (Nessebar City) because the local community perceives the restrictions only as an economic disadvantage.

Thus, we believe that a new bottom-up approach in preservation is needed and attracting the owners and the stakeholders as partners is crucial. For this, we need them to fully comprehend the value behind the heritage. In order to raise awareness and achieve better understanding of the problems, a definition of the addressed target groups is needed. Four main segments were defined: youth (mostly students from special schools such as the Professional High School of Interior Architecture and Woodworking and the Professional High School in Architecture Construction and Geodesy), owners of the buildings with particular historic or aesthetic value for the urban environment, stakeholders with particular investment interest in the field of real estates in historic quarters, and the broad public of non-specialists with no particular interest in cultural heritage issues.

Only on this solid ground a future interdisciplinary and inter-institutionary debate can be fostered.

CREATING A COMMUNICATION STRATEGY

For each and every target group a unique communication strategy is used, accentuating a main feature, closest to the audience group – i.e. the loss of interesting and versatile communal spaces, the loss of physical memory of one's personal memories, the missed opportunity of developing integral project and the loss of environmental spirit and urban aesthetics. On the other hand, the target audiences must not feel accused of being negligent about their property. They must feel as a vital and active part of a dialogue in which their voice is heard and their concerns are taken into account. Thus, instead of feeling helpless, they feel empowered and even more eager to step up. These main factors informed the PR-based communication strategy.

The communication strategy addresses these issues on a professional and nonprofessional level by small personal interventions, by raising an open and honest discussion, by presenting the true complex and multi-layered value of the built heritage (especially the monuments of local importance) as an irreplaceable external memory and bearer of information. It is developed in two main stages. The initial stage is based on reaching the non-professionals and raising awareness among the defined target groups. As a conversation starter a unique postcard is used. It represents the loss of the cultural heritage fabric as carved in the fabric of the paper. The most severely damaged parts of the façade are shown as holes, and the ones that are in intense process of decay are carved as a hatch, rendering the façade of the monument as extremely delicate and fragile (Fig. 7a). This tactile feeling of something too brittle is strengthened by the fact, that the back-side of the postcard becomes unusable – the holes in the fabric obstruct its main purpose as information bearer (Fig. 7b), or makes it unreadable (Fig. 7c). Thus, by a simple perforated postcard with a picture of the monument at risk, the owner, the inhabitant or the other stakeholders feel the loss of the building fabric as a loss of a person's private memories.

Fig. 7a. Postcard as a conversation starter, © W. Nowak

Fig. 7b. MEMENTO MEI POSTCARD: representing the physical loss of urban memory, rendering one's personal memories unusable and lost, © W. Nowak

So far the concept for a postcard used as conversation starter gives unexpectedly good results. Often before any questions are asked, people share stories and their personal experience with their own houses, to give ample insights and details about the struggles they have been through in the process of communication with the co-owners, tenants, administration, designers, etc. Each conversation enriches the understanding of other problematic aspects prior to any repair or reconstruction.

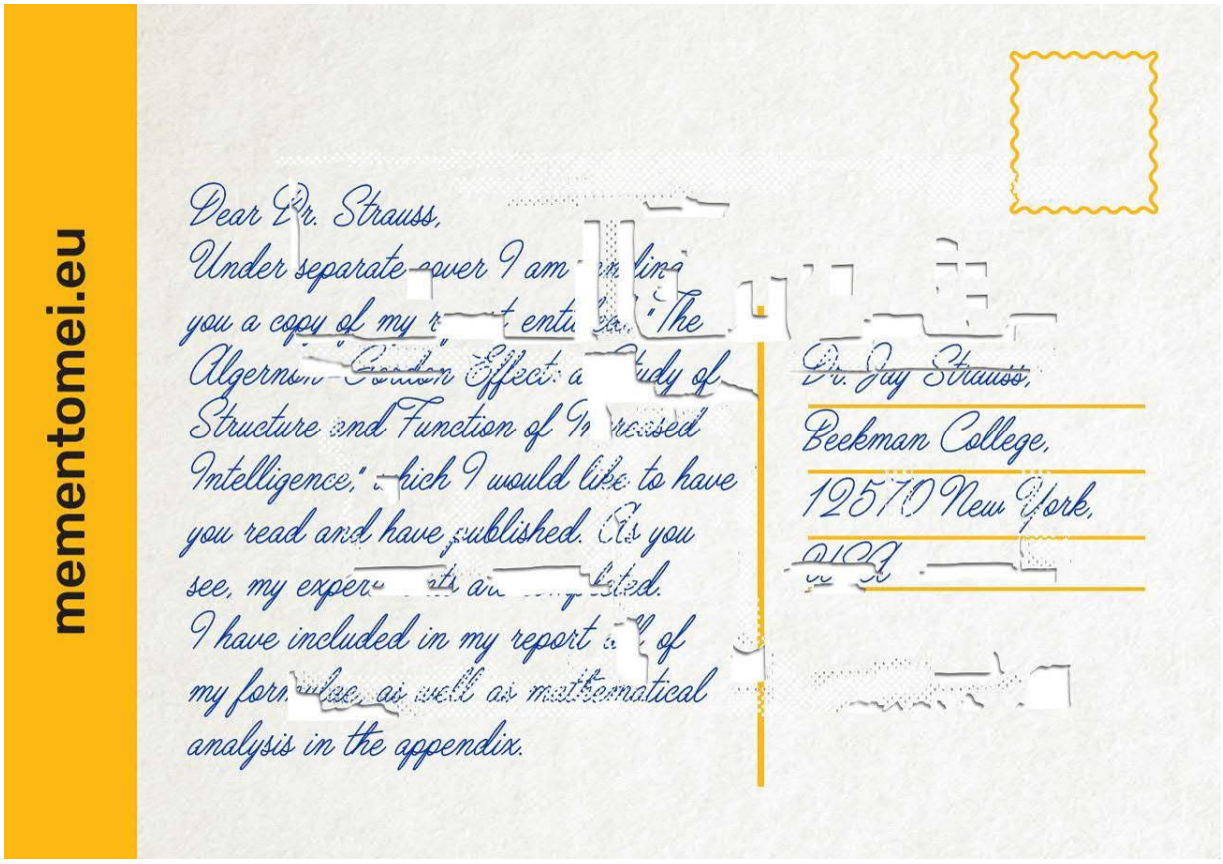


Fig. 7c. Postcard rendering the loss of person's memories, © W. Nowak

The Secondary stage of the communication strategy includes architects, designers, researchers, craftsmen, artisans, workers, along with discussions with diverse audiences. Another key aspect is the involvement of local educational institutions by training students (the soon-to-be artisans) in the specifics of the preservation and in the values of the cultural heritage and its importance for the evolution of a society. Along with that, creating an open network of professionals willing to donate their knowledge and expertise in the process of education and raising awareness on how to take proper care of an old building, as well as to give tidbits of advice on daily, weekly, monthly and annual maintenance practices in order to reduce the need and the cost of urgent conservation and restoration works will be created. The platform includes information about the necessary daily engagement from owners, inhabitants and stakeholders, gives directions for regular inspections and timely and long-lasting care and actions, in order to involve and empower the users of the monument, who are mostly non-specialists and with no particular interest or knowledge about the preservation of cultural heritage. These maintenance and gentle repairs are an economically efficient and sustainable practice, greatly reducing the cost and the need for urgent and expensive future restoration works [McCaig 2013b].

CONCLUSION: MONITORING RESULTS AND FUTURE STEPS

The next step includes the monitoring of the project by analysing and sharing the results in the open platform. The raised awareness on the topic of the cultural heritage significance and the need of its preservation will be measured. The act of the monitoring is a valuable addition to the sustainable preservation practices, further revealing hidden specifics and daily struggles.

By visualizing the effects of the compromised fabric of the cultural heritage as erased pieces of people's own personal fragile memories, we stress on the importance of everyday preservation and proper practices, while building broader and more informed audiences. As part of the monitoring process we introduced to the broad public a map tracing all demolished, about to be demolished buildings, monuments damaged or lost in fire, good and bad

examples and heritage in risk of loss of authenticity[2]. The map keeps track of all protests, conferences and discussions. By making the gathered information public and inviting the viewers to send suggestions we are growing a significant database which spread out of the regional level of the town of Plovdiv and moved on national level and set a ground for a broader discussion (Fig. 8a).

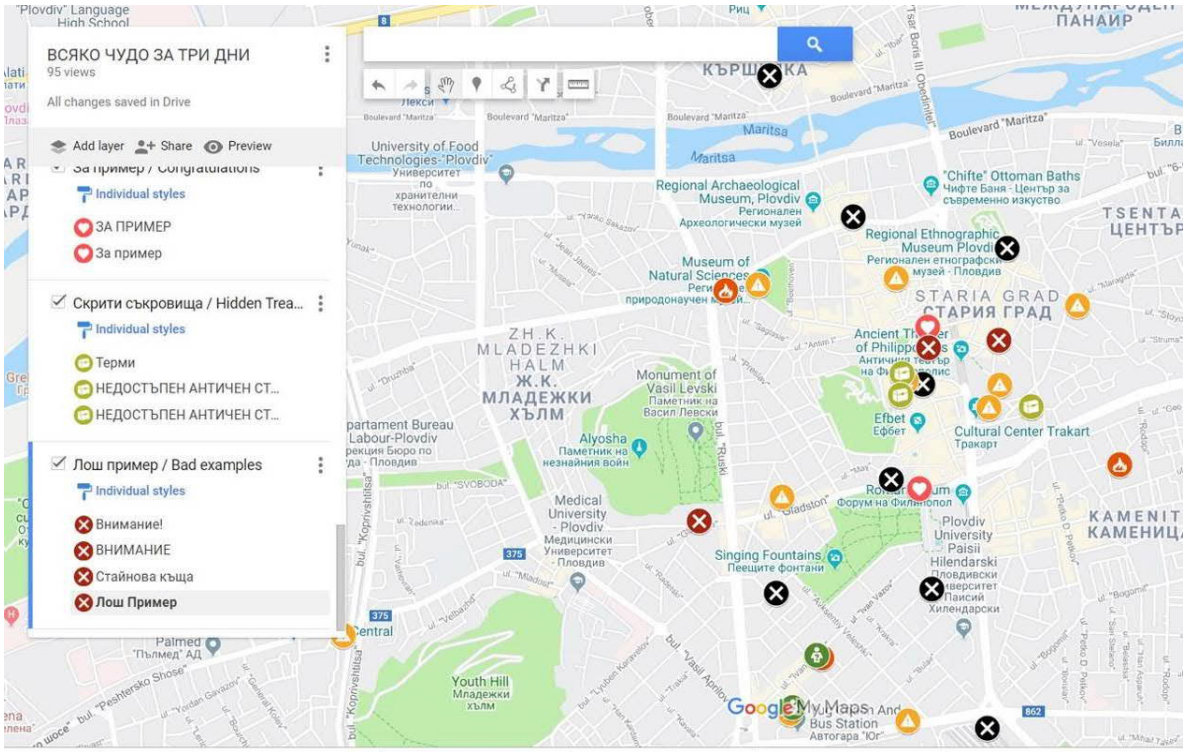


Fig. 8a. Map: demolished heritage, heritage in risk, good and bad examples of preservation (Local level), © N. Toleva-Nowak & W. Nowak

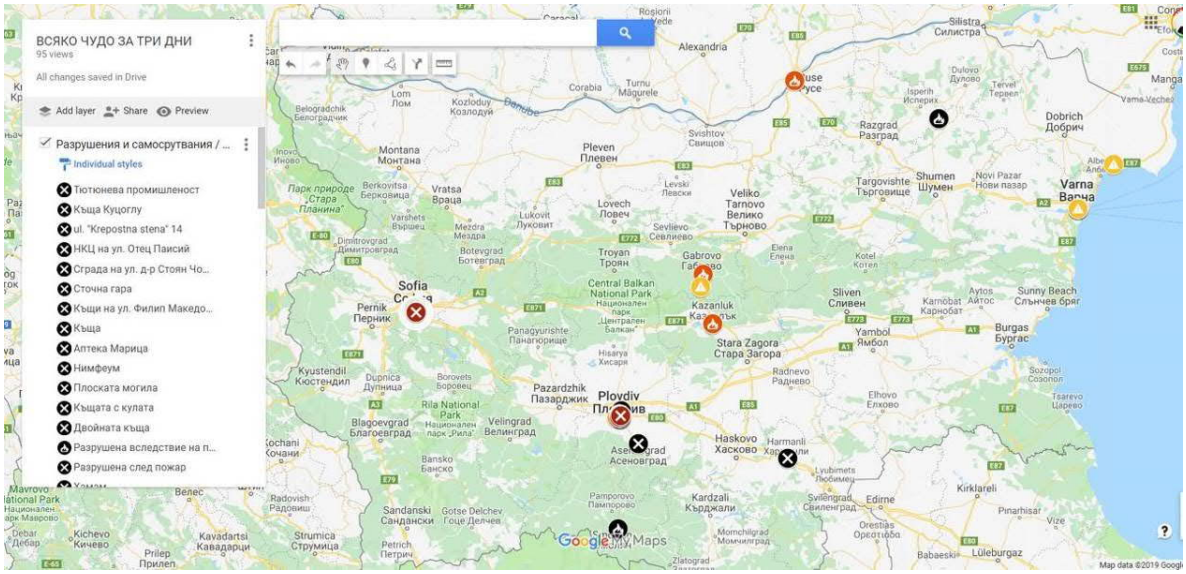


Fig. 8b. Map: demolished heritage, heritage in risk, good and bad examples of preservation (National level, © N. Toleva-Nowak & W. Nowak

[2] https://bit.ly/30t3QWv

The map has enjoyed a good public effect and we have received good feedback and suggestions to add particular monuments in risk to it. The concept of visualizing the additive character of deteriorating heritage – both in one edifice and on the level of a map, increases significantly the awareness across the public and raises more concern than the discussion of an individual case of a demolished/lost monument. Future steps include an online platform that will facilitate discussions of common problems, providing information about laws and regulations and their inconsistencies, and showing how easily executable daily maintenance, gentle repairs and suitable regular care are crucial for the monument's well-being and may delay or even substitute expensive urgent interventions. By expanding the online platform we hope to involve local educational institutions and professional schools and to create a web of professionals who donate their knowledge and prove that preservation is a daily, knowledge-based, not necessarily expensive process. Thus, by achieving higher sensitivity towards cultural heritage issues we still have the chance to pass our history and memories to future generations.

REFERENCES

Athos Agapiou, Dimitrios D. Alexakis, Vasiliki Lysandrou, Apostolos Sarris, Branka Cuca, Kyriacos Themistocleous, and Diofantos G. Hadjimitsis. 2015. Impact of urban sprawl to cultural heritage monuments: The case study of Paphos area in Cyprus. *Journal of Cultural Heritage* 16, no. 5, 671-680.

Thomas Parsons Cooper. 1911. *History of the Castle of York from its Foundation to the Present Day* London: E. Stock.

Svetoslav Georgiev. 2008. *Правен режим на културното наследство в Република България*. Агато.

Richard Harrison (Ed.). 1994. *Manual of heritage management*. Oxford: Butterworth-Heinemann.

Ivan Kabakov. 2018. *Institutions of cultural heritage and the participatory governance*, Библиотека 3:98-104.

Miroslav Krastev. 2016. *Special Features in the Management of Immovable Cultural Heritage.* Строително предприемачество и недвижима собственост, Икономически университет – Варна.

Miroslav Krastev. 2015. *Some Important Problems in the Management of Immovable Cultural Heritage.* Строително предприемачество и недвижима собственост, Икономически университет – Варна; 261-272. https://www.ceeol.com/search/book-detail?id=573016

Abraham H. Maslow. 1943. A Theory of Human Motivation in *Psychological review* 50 (4), 370.

Iain McCaig (Ed.). 2013a. *Practical building conservation: conservation basics*. Ashgate Publishing Ltd. 91-96.

Iain McCaig (Ed.). 2013b. *Practical building conservation: conservation basics*. Ashgate Publishing Ltd. 244.

Hans-Rudolf Meier, M. Petzet, and T. Will. 2007. Cultural heritage and natural disaster in *Risk preparedness and the limits of prevention= Kulturerbe und Naturkatastrophen.*

William Morris. 1877. "Manifesto of the Society for the Protection of Ancient Buildings." *Historical and philosophical issues in the conservation of cultural heritage*. 319-321.

John Ruskin. 2013. The Lamp of Memory (1849). *Historical Perspectives on Preventive Conservation*, 6.

David Spurr. 2012. Figures of Ruin and Restoration: Ruskin and Viollet-le-Duc. In *Architecture and Modern Literature*, 142-61. ANN ARBOR: University of Michigan Press.

Marie Louise Stig Sørensen and Dacia Viejo Rose (Eds.). 2015. *War and Cultural Heritage.* Cambridge University Press.

John Watt (Ed.) 2009. *The Effects of Air Pollution on Cultural Heritage Vol. 6*. Berlin, Germany: Springer.

Imprint:
Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies 2018.
CHNT 23, 2018 (Vienna 2019). http://www.chnt.at/proceedings-chnt-23/
ISBN 978-3-200-06576-5

Editor/Publisher: Museen der Stadt Wien – Stadtarchäologie
Editorial Team: Wolfgang Börner, Susanne Uhlirz
The editor's office is not responsible for the linguistic correctness of the manuscripts.
Authors are responsible for the contents and copyrights of the illustrations/photographs.