Enhancing the digital heritage, educating with the heritage. The Charles V Fort of the harbor of Girgenti

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Abstract

The essay proposes a project of enhancement and valorization of the Fort of Charles V to guard the harbor of Agrigento, in 1549. Starting from those visual references testified by the sixteenth and seventeenth century representations between the defensive fort, the harbor of Agrigento, and the ancient Greek city taking shape in the landscape configurations of Camiliani and Spannocchi, the article proposes the enhancement of the building starting from a photogrammetric digital survey with a phase of digital elaboration of the model on virtual platforms for the immersive exploration to be concluded with the definition of paths differentiated by users from a wide range of sources (scholars, citizens, students of different ages).

Keywords: Iconography, redrawing, digital modeling, VR.

1. Introduction

The cultural heritage, and in particular the built heritage, is living a period of great ferment due to the application of technologies of three-dimensional modeling, realistic visualization and, even more, Virtual, Augmented and Mixed Reality. Being able to experience realistic immersive environments of inaccessible spaces (because they are far away, or they have not yet been built, or they no longer exist, etc.) opens up many possibilities for education in the historical, artistic and architectural heritage. Heritage education does not mean perpetuating the "cult of the past", but it means making sure that heritage itself remains alive and still has a future. It is a certain acquisition that defines heritage education – which necessarily goes through an experiential phase– "as a formal and informal formative activity, which while educating to knowledge and respect for goods, with the adoption of responsible behavior, makes heritage the concrete object

of research and interpretation, adopting the perspective of recurring and permanent training to active citizenship and responsible for all people". (Bortolotti, *et. al*., 2008). So, if digital technologies allow not only to make possible these experiences to anyone who is connected to or has access to the device of representation but allow to increase the real experience by adding information, visualizations, possibility of interrogating the heritage itself, it is clear that the preferential environment of education to historical and architectural heritage is, necessarily, digital (Luigini, Panciroli, 2018; Luigini, 2019). The paper will present the historical and iconographic research, its interpretation, the phases of the survey, the construction of the representation device and the short conclusions drawn from the experimentation of a "beta version" of the designed Serious Game.

2. From the cartographic representation to the views of the Charles V Fort

The historical events which characterized Sicily, closely connected to the geographical position of the island in the middle of the Mediterranean, outlined a plot of relations between different countries and cultures. A significant historical bibliography reports the maritime activities on the shippers of the Agrigento coast included in the commercial circuit operating with both Greece and Carthage. In fact, already known as the *Emporium* during the Roman period, the shipper used to export grain was defined by the historian Strabo as "the most remarkable port of the southern coast" (Allotta, 1998, p. 22).

In the ninth century, the urban expansion of the city suggested the new site of Porto Empedocle, which was characterized by a much more pronounced bay than the current one. The connection between the city and the port was offered by the old way connecting the district known as ra-bad, the outer borough, to the sea. Large underground silos were excavated in the same area of the shipper (Peri, 1962). Shortly after the Muslim conquest, commercial production stimulated population growth, but it was between the four-teenth and fifteenth centuries that the Sicilian coasts became a place of transformation and progressive construction of a fortified and closed defensive system.
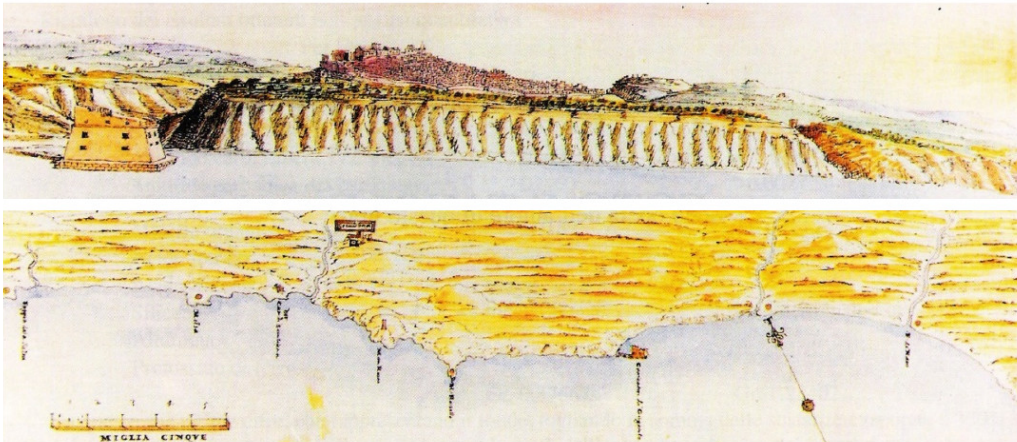

Fig. 1. Drawing by T. Spannocchi (1587) of Agrigento with the Fort of Charles V on the left (Dufour, 1992, p. 385).

Following the crisis experienced in the Byzantine era Agrigento regains its Mediterranean dimension, its port allowed to supply all types of agricultural production especially promoting the export of wheat. The *Girgenti* shipper was already known among the coastal castles of the royal state property at the beginning of the 1400s and was part of a fortified system of towers along the southern coasts of Sicily in defense of the Saracen incursions.

2.1. On the cartography of the coastal territory

The wars of the sixteenth century in the Mediterranean were followed by the development of new weapons, shipbuilding and construction; therefore, the surveys on the territory included not only the major cities of the eastern coast, but also the western and southern circuit. It is a graphic collection on the island's coastal territory which record the demographic development, the economic condition and a detailed panorama of the Sicilian viceroyalty. Some of the elements that characterize the first representations of the Agrigento's coast concern the essential aspects of the territory: landings, morphology of the rocks, winds, depth of the waters, presence of vegetation and estuaries of the rivers (Fig. 1). These elements were integrated with legends that recognize the buildings of the dock and their use destination. The representations of Tiburzio Spannocchi (1543) and Camillo Camiliani

(1574) are part of the great project of detailed survey of the Sicilian coast on behalf of the Kingdom Deputation with the aim of cataloguing the existing defense structures in the territory and those to be built. In this regard, a report that Camiliani drafted in 1583 on behalf of the viceroy Marco Antonio Colonna mentions: "una rocca molto forte, […] fatta modernamente per la sicurezza del formento" (Allotta, 1998, p. 79). The royal architect refers to the strong bastion that the viceroy Giovanni De Vega had built in 1554 to defend the shipper. It was one of the bastions built to defend the coast of Agrigento against the invasions of pirates, during the reign of Charles V.
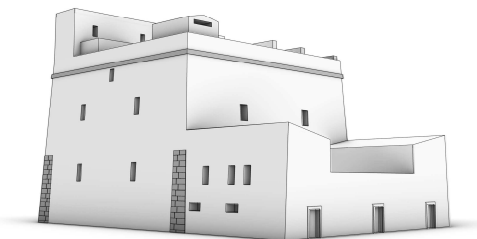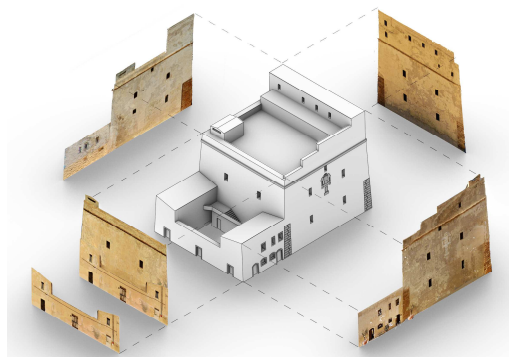

Fig. 2. Exploded axonometric and perspective views of the digital model of the Fort of Carlo V.

Regarding to the architectural typology, probably the square plan adopted for the construction of the tower has not undergone significant alterations until the Middle Ages, unlike the construction techniques and the size of the building. Some surveys from 1823, by the Austrian soldiers commissioned by von Caboga, restore the configuration of the dock of *Girgenti*, completed in 1763, which allowed the anchoring of large war galleys. Later, since 1780 the tower served as a penal colony maintaining the function of prison after the unification of Italy.

2.2. On the architectural typology of the fort

The tower of the Agrigento's shipper, or *turris maritimae Girgenti*, also known as the tower of Charles V, is part of the historic location of the Val di Mazara which included western Sicily with the current provinces of Trapani, Palermo and Agrigento. The first information dates back to about 1355, when the tower is mentioned in a Pisan list of Sicilian castles. In 1357 it was also mentioned as *turris maritimae* and later, in 1361, was granted by King Federico IV to Federico Chiaramonte. Between the fifteenth and six-teenth centuries, the ladders were partially transformed and became an integral part of the architectural structure; in fact, as can be seen from the representations of Camiliani, to reach the height of the first floor, is made an inclined plane to facilitate the transport of wheat's bags, no more existing in the configuration of the tower used as a penal colony (Fig. 2). To defend from high pitches, in correspondence with the *astracus* (from the Latin word *astracu,-um*), *i.e.* the open terrace created to the upper floor of the tower, a parapet was built along three sides of the fort which, on the side opposite the sea, develops for the entire height of a volume obtained longitudinally with a single pitched roof inclined towards the inside. On the orders of the viceroy de Vega, in 1554 the medieval tower was entirely rebuilt with squared blocks of limestone and shapeless stones, assuming the current configuration of a square plan of about 27 m side and truncated pyramid elevation.

The architectural body, characterized by an external masonry that reaches 4,20 m thick, develops on two levels marked by two orders of windows. It is bordered by a strong string-course
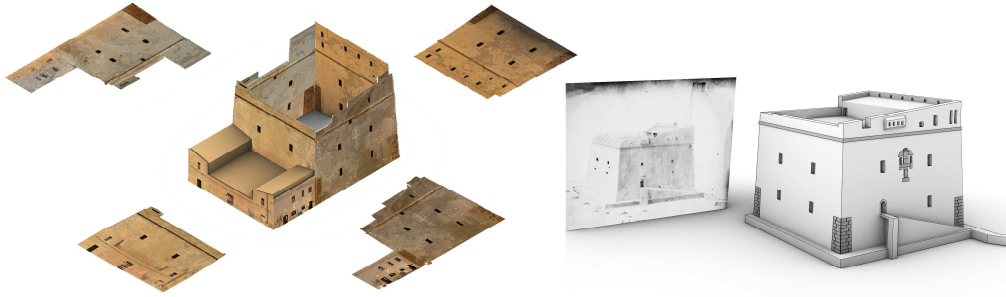
Fig. 3. Left, axonometric schema with photoplans; right, perspective view of the digital model.

ribbon placed about 22 m from the ground and by a parapet along the upper perimeter to protect the *astracus*. It is strongly raised at the side of the earth and much lower on the opposite side to allow the use of artillery. The tower, built on a sloping base, to obtain a greater structural reinforcement, is described graphically with a long access ramp that reaches a raised entrance compared to the level of the ground floor. The ground floor, occupied by the drinking water tank, was to constitute a valuable reservoir for water supply, especially in the case of a prolonged siege (Fig. 3). In the centre, a cylindrical body protects the spiral staircase, *caracol*, which connects the two levels with the *astracus*. The first floor, used for the use of towers, consists of four-square rooms defined by two thick cross-shaped walls, 2,10 m, interrupted at the four access openings in the masonry. The second level is characterized by two large rectangular rooms each covered by a barrel vault. In correspondence with the distance between the two windows on the second level, the big coat of arms of Charles V in white marble has been inserted. In fact, the coastal tower, erected near the loader, delimits a defensive system that characterizes the Sicilian baronial economy, constituting a further prerogative for commercial dynamism and ensuring the security of the warehouses (Lesnes, 2000). The geographical and landscape studies carried out by erudite travellers as early as the sixteenth century are part of a graphic work of exploration and detailed investigation of the territorial and economic characteristics so as to provide an overview of the reality of Sicily: graphic documents such as the views made by

Tiburzio Spannocchi or Camillo Camiliani accompanied by reports on the status of the places, are the evidence of a multiple vision not only of the existing, but also on the project of the new.

3. Acquisition procedures and case study Reconfiguration

The photogrammetric survey of the artifact at the current stage was carried out through the use of low-cost equipment for the acquisition of photographs, a Kodak Pixpro orbit 360 integrated with a common mid-range Sony Digital SLR camera, while the data were processed using the photomodelling software Agisoft Metashape (Fig. 4). The purpose of the survey was to obtain a digital 3D model corresponding to the volumetric and proportional level to the real one, from which it was possible to generate backwards a series of models that represented the original configuration of the various age.

Despite the fact that the fortified structure has no articulated complexity, over the centuries it has undergone numerous modifications, only partly documented by historical iconography, with nineteenth-century perspective views, elevations and plans, in some cases pseudo-axonometries. For this reason it was decided to associate the historical documentary data with a survey of the current state, on the one hand to understand what are the signs, traces, which over time have been preserved, in part to verify the accuracy of the previous surveys. The objective is to obtain a series of three-dimensional models which can be placed in a serious game for a museum application functional to a visual-interactive divulgation
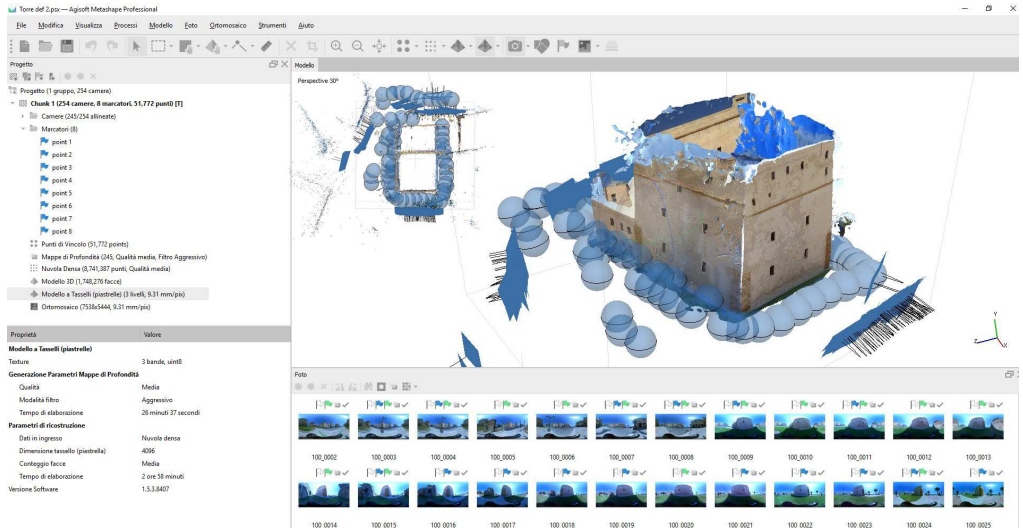
Fig. 4. Texture mesh model from Metashape.

that can explain quickly, and to a diversified target, how the architectural structure has evolved from the time of its origin until today. The fortified tower dominates the view from the sea of Porto Empedocle, where there was the port of Agrigento, at a delicate roads junction, where traffic is continuous especially during the hours of day, more appropriate to the photogrammetric survey, which, based on the photo shooting, is particularly sensitive to lighting conditions. It was therefore necessary to carry out the actions for data acquisition as quickly as possible, following a precise plan of survey developed on precisely predetermined paths on previously drawn up plans and satellite aerial photos. Carried out in about two hours on site, it was deliberately chosen to take pictures following two linear paths around the building, one with a traditional reflex camera, with progressive shooting methods, taking pictures parallel to the facades of the building through the technique of cross, the other, scan thinner, based on the shooting ORBIT 360, which offers immediate structural plastic restitution complete also in relation to the surrounding environment, thus using an integrated acquisition technique that usually speeds up operations in the interior architecture but can offer a very immediate and versatile management even for outdoor shooting. Before entering the photos for the calculation, we moved on to a

post-production phase, in order to homogenize the chromatic aspect of the photos taken by reflex with that of the equirectangular panoramas, fundamental step because the information contained in the photos taken by the two different tools were then entered into a single software for the generation of photogrammetric point clouds, Agisoft Metashape, which interprets the corresponding points of the multiple shots in the 3D space after the alignment of the photos, basing on the quality of the color of the pixels. It was therefore necessary to eliminate the dominant colors and homogenize the color temperature as much as possible so that the program could recognize the connection of several shots, those from parallel scanning, among other things taken with different focal lengths, and those with equirectangular spherical mode. The procedure has given excellent results without the use of multiple chunks.

The three-dimensional model obtained from the photogrammetry served as a precise reference to make a correct modeling Nurbs: on the one hand, the parallel projection photoplans (Fig. 3) generated by Metashape were used to calculate the exact size and arrangement of the windows on the facade and the plastic composition of the exposed stone, which is now left exclusively on the cantons at the external corners of the
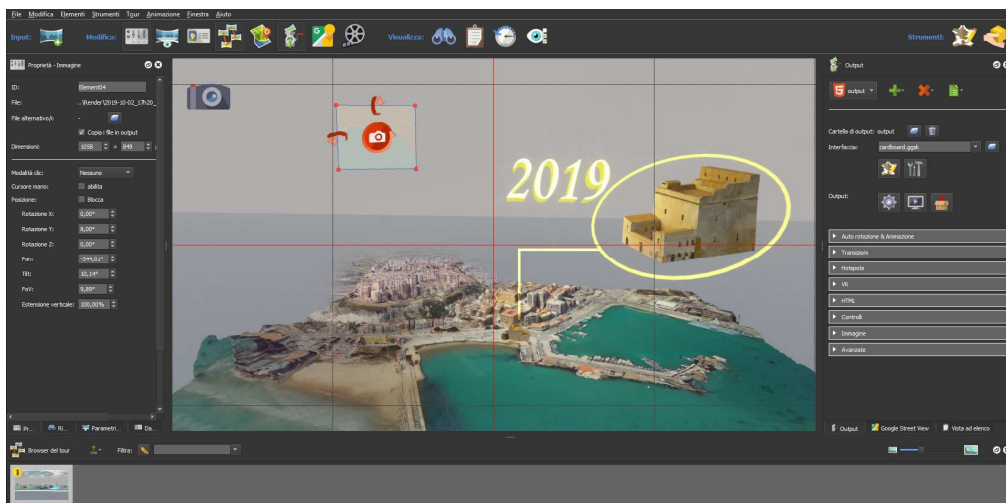
Fig. 5. Pano 2VR serious game interface.

structure, not plastered; on the other hand, the inclination of the facades, the general arrangement of the architectural apparatus and its different proportional ratios, especially in the upper parts, were analyzed using the three-dimensional texturized model automatically generated by the photogrammetric software, exploiting as vertices of the polygon meshes the points from dense clouds. Once the tower was modelled in its current state, following the written-graphic historical sources, the necessary variations were made to reconfigure the model according to its evolutionary conformation in 4 historical periods. Considering the divulging nature of the operation and the lack of precise information on the most distant historical periods, it was preferred to reduce the number of hypotheses of digital reconfiguration of the building without following a synchronous generalization with the periods treated, with the aim of showing, in the perspective of a serious game, how the building has actually changed over time, even on the basis of the surrounding territory. The procedure was therefore a study that included a backward analysis of the distinctive signs of the artifact, modified over time or persistent in the current configuration, also taking into account very carefully the territorial changes, where the sea, gradually over time and in a rather marginal form, has withdrawn. For the texturing of the models the

editing process was similar to that of the modeling, in part the data were reproduced starting from the current photographic images, then on the basis of an analysis of historical iconographies we assumed the most appropriate configuration. Through photo retouching we proceeded with the elimination of digital disturbance, such as cables or posters and written on the wall apparatus, obtaining a homogeneous appearance of the textures for the wall coverings hypothesized in various ages (Fig. 5). Sampling the unpainted part of the cantonal and mixing this information from a photoplan with photographic data derived from materials chosen for philological similarity, we then reconstructed the effect of the original coating, common according to our research to almost all the ages, and persistent until the last restoration of the tower[1]. For the current territory, a textured model has been generated, again through a photogrammetric process, from 3D aerial data acquired by Google (Palestini, Basso, 2019).

For the environmental rendering relative to past periods, reference was made to a more pictorial interpretation of the territory relating to the withdrawal of the sea and the coast configuration, given by historical maps. The textures in .tiff format were then applied by UVMap projection on the 4 reconfigured models ready for export in .obj format on the digital compositing

Fig. 6. Historical reconfiguration with animations and infographics of the digital model of the Fort of Charles V and historical cartography.

platform, through which, once the assembly of the different assets had been carried out and the refinements and graphic corrections added, it was possible to proceed with the pre-rendered 360 video and with the possible definition of a fully explorable scene compatible with the virtual interactive platforms aimed at obtaining a serious game of higher complexity.

3.1. A time trip through the Serious game

Generating the four three-dimensional models and a part of the territory that hosts them, concerning each historical period examined, a 3D graphic application was designed that gave the possibility to view at the same time the various eras in order to originate constructive interaction by the observer, placed in the center of a rotating disk, on the perimeter of which are arranged the four historical reconfigurations where the animations take place in loops and the infographics that tell the specific historical evolution and the related events of the past (Fig. 6). The final compilation of the virtual tour has therefore different complexities depending on the use you want to make of it: if you use only a desktop view, compatible with any smartphone or tablet, a 360 video in loop allows to view the effective evolution of the architectural artifact and offers additional information with a simple point and click system[2]. Much more interesting is the possible configuration for an interactive stereoscopic active VR system, through which, with the use of headsets such as Oculus Rift S, it is possible

to explore at various levels of depth, the 3D models, decompose them or section them in order to view the internal configuration and, possibly, have the opportunity to get inside without necessarily following a predetermined path[3]. The idea of an VR system could include the various reconstructions proposed, with the possibility of passing from one configuration to another through time jumps, allowing in real time to understand the actual changes of the artifact. This design hypothesis logically involves, in the digital reconfiguration of the models, an improvement of the structural detail while today they turn out to be conceived only for use in interactive applications pre-rendered by desktop.

4. Conclusions

Communication and education on Cultural Heritage are, as widely demonstrated by the international and national debate, a necessary condition on which to base strategies for the conservation and enhancement of cultural and natural heritage and, consequently, also the activities of tourism promotion and provision of services to the public (Trizio, *et al.*, 2019). This ground has inspired all the design phases of the Charles V tower's enhancement device. The integration of an in-depth study from the historical and iconographic point of view, of the photogrammetric survey with different methodologies (form flat and equirectangular picture) of the serious game design and the pedagogical skills has allowed to design an effective didactic path, able to make

the history and the architectural qualities of the building known, but also to revitalize the building itself. The tests carried out have shown how the representation device is flexible and adaptable both to an adult audience and to an audience of children and young people, crossing and joining, in fact, several generations in the experience of heritage. This interdisciplinary and intergenerational character is a point of development that seems to us to be significant and that we believe is a valid line of development for the enhancement of heritage.

Notes

[1] The tower of Charles V is now presented with a plastered coating. The corners of the structure, fortified cantonals, have been left exposed, preserving the original structure.

[2] In this case the potential of software such as Pano2VR, one of the best Virtual Tour makers on the market, would be exploited.

[3] This configuration contemplates the use of more complex software, suitable for rendering in real time thanks to the latest generation GPUs.

Credits

Although the contribution was argued jointly by the authors; A. Basso wrote paragraph 3; S. Vattano, paragraph 2; and A. Luigini paragraphs 1 and 4. The figs. 2 and 3 are elaborated by S. Vattano; figs. 4, 5 and 6 by A. Basso.

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