Digital Twin: a new perspective for Cultural Heritage management and enjoyment

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ABSTRACT

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1. the 3d survey

All this is made possible starting from a three-dimensional model of the underground oil mill, from which the stereoscopic panoramas have been extracted. Stereoscopy is very important for the full success of the project. In effect tis his is the aspect on which the level of interest induced in the visitor depends the most. The immersiveness induced by stereoscopic vision is part of an empathic mechanism that can be expressed in the ability to emotionally involve the viewer with a message in which he is led to identify with. As a result, the user will tend to consider the two distinct objects, the digital twin and the real context, as if they were one and the same thing. He may then accept that, during the virtual experience, many of the aspects perceptible only during a real visit can be understood. The immersiveness, if is accompanied by the realism of the restitution, is therefore decisive in considering that the vision obtained with simple 360º panoramas is comparable to that obtainable with a 3D model explorable in real time with hi-end viewers. We can say that the ability to generate emotion and amazement, combined with the sense of presence, is an important element in generating interest and attention during the visit. As a result, greater interest and attention will lead to greater understanding of the communicated message. This explains some of the effort put into generating a 3D model from which stereoscopic panoramas can be derived. Of course, the current technological landscape offers several solutions to obtain stereoscopic panoramas, in most cases obtainable with simple photos. Some manufacturers offer dedicated hardware with up to 12K resolution. The differences between image-based solution and full 3D method are substantial and obvious, but it is worth mentioning here some of the main differences and criticalities inherent in the two methods.

Figure 3. Final 3D model after bake texturing process. The starting point of digital twin.

First of all, the pano 360° obtained from photos do not allow to determine the surface morphology of the object, consequently they do not yield metric information in XYZ space. This is a crucial aspect in the use of digital twins since they are characterized by the intimate connection between 3D topology and real space. In the absence of a 3D morphology, it will not be possible to link information derived from sensors and archaeometric, structural and microclimatic analyses relating to specific parts of the asset in study. Just think of the georeferenced superimposition of information and its reading according to layers organized by categories, which is impossible to properly achieve on photographic pano. In the case study presented here, the stereoscopic panos is therefore only one of many media that can be obtained from the 3D model. This is not a starting point but a reading output of the information produced, subsequently organized according to the paradigms of a VR visit. It seems therefore undoubted that the effort to be achieved is to obtain an accurate three-dimensional model, on which all the data relative to the management of the real space connected to its analogous 3D topological space can be hooked. This can be conceived as a geometric space of polygons and as a body of information correlated to the surface colour.

For the virtual use of the collected digital resources, it is crucial to have an extremely realistic three-dimensional model. Realism in this case is not aimed at a cinematic level of representation, but at the best correspondence with the actual state. To this end, a complete three-dimensional model was created using digital photogrammetry techniques, which are now widely used and known to all. The three-dimensional restitution posed many problems of coverage in the hidden areas and of management of photo shooting due to the poor interior lighting, but also to the precise need to obtain a digital twin that restores the same "genius loci" as the real space. In fact, we have deliberately kept the atmosphere of the real space, without making it too artificial or illuminated in a different way than the real space. Approximately 3000 high-resolution photos (21 Mpixel) were then generated, resulting in a mesh resolution of approximately 0.4 mm, which is more than acceptable for the purposes of the project and the size of the mill (approximately 250 mq). The measurements were georeferenced with coded targets, whose coordinates were recorded with a total station.

This has made it possible to keep high the accuracy of the measurements, while keeping fixed the constraints. Due to the computational complexity of the photogrammetric model, the calculation was divided by zones with overlapping of about 10 cm. The main orientation (sparse cloud) was generated for the entire set of photographs, while the dense clouds were calculated in several patches. This solution solves many memory and computation problems, which often prevent the completion of digital photogrammetry projects characterized by a large number of photos. The orientation of the sparse cloud is actually not a very hard problem in terms of calculation, even with huge sets of photos, it is therefore possible to calculate individual chunks while maintaining the correct referencing. The spatial position of the different chunks will be respected even in case of an export to modeling software or BIM.

Regarding the texturing process, a texture with a resolution of 15000x15000 pixels was calculated for each of the several portions of the model. This process, as expected, causing several problems due to the poor lighting of the interior and the need to shoot the photos with the camera gripped. Therefore, a new set of images was created to solve blurring anomalies induced by depth of field and relatively long shutter speeds (often 1/60 sec). From an operational point of view, the sparse cloud was then calculated with the entire set of photos. In the last phase dedicated to the texturing only the photos taken ad hoc for this purpose were enabled. Basically we built a very large set of photos needed to get good geometric detail and a set of about 400 photos dedicated to the texturing. The final result is shown in the figures on these pages.

1. CONCLUSIONS

All From a morphological point of view, the digital model of the oil mill is therefore a reliable replica of its physical reference. In the case of extraction machines that are no longer conserved, one- and two-screw presses have been included in the virtual tour, taken with the same 3D techniques from other similar contexts. Since photogrammetry ensures excellent accuracy even of the colour data, the 3D model is ready for all subsequent implementations concerning the state of conservation, measurement of volumes, static verification in relation to loads and road surfaces, calculation of energy requirements, etc. At the moment the digital twin allows groups of users to visit remotely this context, in immersive way, with the possibility of extending the visit to other contexts that can follow this management philosophy. This aspect related to the visualization and use of data belongs to one of the purposes of using these digital resources. The main difference to a classic 3D navigable scenario or a classic virtual tour is a new perspective on the use of these models. They are no longer created with the exclusive objective of obtaining a survey of the actual state, but respond to a new management requirement, which takes into account the potential of 5G, the greater computational capacity of portable devices and IoT (Internet of Things). The 3D object in this case is a 'thing' that has its own consistency, certainly digital and immaterial, but tangible and useful for the management of the physical asset.

Regarding innvativeness in visiting, the live-guided tours are probably the only system available today for a shared virtual tour. But what are the other elements of interest in this project? Firstly the benefits offered by the distant visit modality, in the context of the current pandemic emergency. Not less important the possibility of virtual access for the disabled, in a multi-user and multi-platform environment. Finally the technological appeal given by the immersive vision and the potentialities related to the digital twin philosophy, still not fully explored in the Cultural Heritage sector.

The long-term goal for us is the creation of an advanced management model. The association between physical object and virtual reality makes it possible to activate a data analysis and monitoring of the systems in such a way that it is possible to operate in predictive mode, identifying problems even before they occur. In addition to preventing anomalies, downtime and inefficiencies, it is possible to develop new opportunities using appropriate simulations and planning future business. By creating a digital twin, it is possible to better understand how to optimize operations, increase efficiency or discover a problem before it happens. The creation of digital twins related to cultural heritage allows the making of models representative of reality, to be used for conservation purposes, for knowledge and for overcoming physical and cognitive barriers.

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