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Digital Graphic Survey of Funerary Architecture - The "Museum of Silence" of the General Cemetery of Valencia

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Abstract

Currently, techniques for obtaining 3D models are booming due to the infinite applications of these models. Photogrammetry by SfM (Structure from Motion) is a whole new subject that is emerging in this field of modelling, as it is a technique that allows us to obtain high-resolution 3D models with a camera. This project will address the study of this new subject and its application in the development of 3D models, as well as the workflow with other capture techniques, such as laser scanning and its possible virtual applications.

Currently, the most precise method to capture 3D information is the laser scanner, but it has weaknesses, which are precisely one of the strong points of SfM photogrammetry.

A brief tour will be made of all the techniques that exist to give photorealism to a terrestrial laser scanner (TLS) scan, to then present the developed and proposed technique on a real example and, in this way, obtain conclusions.

In the end, the solution is proposed to the Museum of Silence, where, with augmented reality, options are proposed to safeguard the Funerary Heritage from theft with the creation of virtual models, 3D reproductions of sculptures and other elements that are victims of vandalism.

Keywords: *digital, funerary architecture, Museum of Silence, cemetery, Valencia.*

1. Introduction

With this presentation, we want to show the problems that occur with a Heritage that is abandoned, that is of no interest and that some politicians (with positions in Culture) went so far as to say that "these constructions, the best thing was demolish them and make them disappear" in order to help the urban growth of the "Cities of the living".

Yes, we are referring to the "Cities of the Dead", our Cemeteries. Spaces that bring together a variety of architectural styles and that bring together all or almost all of the so-called "Fine Arts".

We talk about Cemeteries but not about the Cemetery as a container; we want to talk about the "Content" of those constructions that, as we mentioned before, bring together almost all the Fine Arts, although in Latin American countries (much more respectful than us in the protection of this heritage), they do use all the Fine Arts, since paint is used to give life and colour to these spaces. In this way, in Latin America (in a large part of it), when painting these constructions, they give joy and life to these spaces; spaces that in Europe are overshadowed by a feeling of sobriety and austerity. This sensation is perhaps caused by using nobler materials, which are not used in Latin America and which force the periodic painting of their walls.

But in order to do what we want, we must carefully study how to graphically construct these small constructions and make clear how to name them.

If we go to the Royal Academy of the Spanish Language, it tells us:

Pantheon: *Funerary monument intended for the burial of several people*.

Mausoleum: *Magnificent and sumptuous tomb.*

For Spain, it is clear. We can say that in Europe, the constructions of our cemeteries are Pantheons, and the very large constructions are Mausoleums, but in Latin America, that difference of very large -or for them large- is where a clash of lexical variation occurs. To avoid creating confusion, let's talk about the fact that those constructions of more than 4-5 meters in height or width are called Mausoleum.

Once this point has been clarified, we will make it clear that we care little or nothing about differentiating between these two terms; we care about their artistic quality. We will not go into the possible economic aspects of these constructions and whether they demonstrate or define the economic power of the family buried in this space. We look for artistic quality.

Let us make it clear that in a Cemetery you can find constructions worthy of being classified as truly monstrous or worthy of a "Museum of Horrors". We want to stay with what truly has quality or with those elements whose complements, outside of architecture and within the fine arts minors, give quality and originality to these.

As we indicate in the summary of this Communication, currently, the techniques for obtaining 3D models are booming due to the infinite applications of these models. SfM photogrammetry is a new topic that is emerging in this field of modelling since it is a technique that allows us to obtain high-resolution 3D models with a camera. This project will address the study of this new topic and its application in the development of 3D models, as well as the workflow with other capture techniques, such as laser scanning and its possible virtual applications.

Currently, the most accurate method for capturing 3D information is the laser scanner, but it has weaknesses, which are precisely one of the strengths of SfM photogrammetry.

A brief tour will be made of all the techniques that exist to give photorealism to a scan with a terrestrial laser scanner (TLS), to then present the developed and proposed technique on a real example and, in this way, obtain conclusions (Bonafé Cervera, 2016).

In the end, the solution proposed is the Museum of Silence, where augmented reality options are proposed to safeguard the Funerary Heritage from looting, with the creation of virtual models, 3D reproductions of sculptures and other elements that are victims of vandalism.

Many of us think that looting ends in an undesirable end for these constructions; we are talking about vandalism in Cemeteries, where political graffiti occurs on Pantheons of politicians or renowned figures, destruction of sculptures due to attempts to steal them, etc. A lack of respect not for the person who is buried there but for the Heritage.

2. Aims and Objectives

2.1. Purpose. Choose the most appropriate method

The purpose is to apply most of the known systems for the graphic survey of this heritage, but little or nothing is studied. Abandoned on many occasions by administrations because "the dead person does not vote", and it is not interesting to invest money in a space where it cannot be seen.

Photo modelling, through its different techniques, constitutes today a valuable photogrammetric method that offers reliable results because its means are within the reach of anyone and because it has enormous versatility in the field of 3D modelling (Beraldin et al., 2002).

Until recently, close-object photogrammetry, known as such, aimed to model objects through a few photographs, in which homologous points could be observed in three or more frames. Knowing the calibration of the camera with which the photographs had been taken, through the marking of these homologous points, the orientation of the cameras was obtained through the collinearity and coplanarity equations. This technique encountered serious limitations due to the number of cameras due to manual point marking.

With the appearance of the new Structure from Motion (SfM) technique, they overcome the limitations of manual intervention in the process.

SfM is derived from developments in artificial vision with automatic feature recognition. Although these were initially focused only on aerial photogrammetry and robotics, in the last twenty years, efforts have been made to resolve the complexity of the sets of convergent shots and, in turn, respond to the demand for an acceptable visual quality in the results. Thus, in a few years, a good number of applications have been developed in fields such as photogrammetric surveying, reconstruction of objects from video sequences, and automatic reconstruction of virtual reality (so that, for example, computer-generated objects can be integrated with real scenes), or macro-panoramic, based on these principles. Above all, the field in which this technique is and will be emerging is in modelling with drones, since today it is only possible with photogrammetry since the use of a laser scanner mounted on a drone is unfeasible until sufficient technology to create a light enough emitter.

SfM works with different types of algorithms, and within each type, there are many versions since each developer contributes improvements through an unstoppable evolution process. Different phases can be differentiated in the alignment of the cameras:

We will talk:

- Key point detection with SIFT Algorithms;
- Matching key points found between groups of images;
- Refinement by robust fitting algorithms;
- Camera orientation.

To talk later about the techniques for the integration of photogrammetry and laser 3D scanning.

Briefly knowing the SfM algorithms interests us to the extent that it can help us in our purpose of developing an adequate operational technique for the digitisation of buildings and urban scenarios from photo sequences or video sequences depending on the destination and the accepted precision. of our work.

Very broadly, the operation of the Scale Invariant Feature Transform (SIFT) algorithm, which happens to be the first to be published, is based on the search throughout the entire image for pixels with high contrast in relation to the surrounding ones, such as belonging to edges or corners. The results are called keypoints and are defined by their pixel coordinates and by a "descriptor", which is a vector that represents a three-dimensional histogram of the characteristics of adjacent pixels according to certain directions. Most applications generate a file for each frame that contains the image coordinates of the detected key points of said frame; many authors call these files as .sift files. (Figure 1).

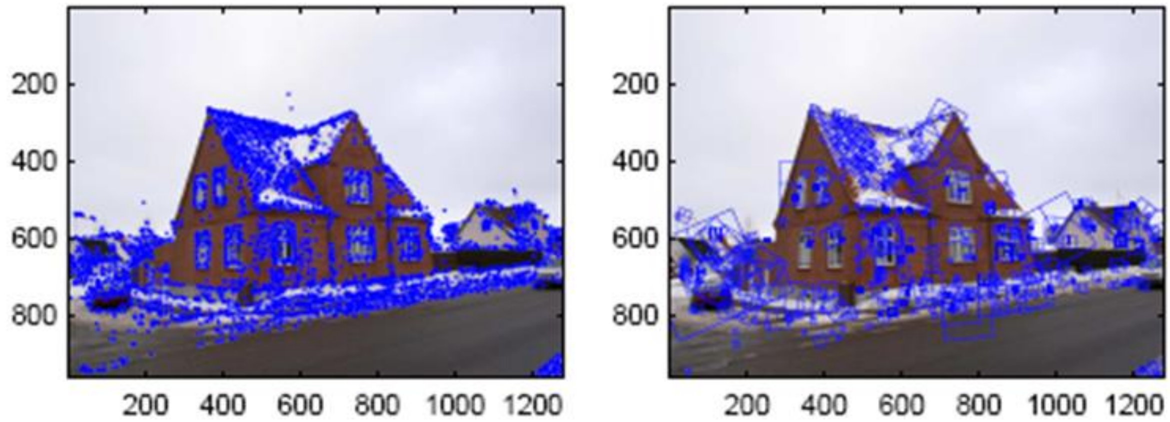

Figure 1. Keypoint Detection with SIFT.

Next, correlation algorithms (matching) are executed between the corresponding points of the different pairs of images, generally known as area-based or signal-based type, and which, in the case of SIFT, are specified in the "method of the nearest neighbour." This essentially consists of calculating the coincidence between the descriptor of a key point of the initial image and those located in the second image, within a certain search area, according to their gradients in multiple directions, and considering the correspondence good when the divergence is minimal.

The matching between keypoints is done between two .sift files (containing the coordinates and characteristics of the keypoints). Each .sift file will match all the remaining .sift files that we want or that the program or application requires. For example, the Photoscan software offers three matching quality options, depending on whether each one will relate everything to everyone or follow a correlation order (Figure 2).

The inevitable errors of this experimental process in this first matching, due to occultation, reflections, or other causes, are then refined using robust adjustment algorithms. If enough points have been obtained for the next orientation phase, this phase will be concluded; otherwise, more co-correlations will be searched. In this way, a loop will be formed that will be closed when the need for correlated points for the orientation of the cameras is satisfied (Cabanes, 2020).

Figure 2. Matching with 12 Images. Romanesque door of the Cathedral of Valencia.

With these data, it is possible to approach the “projective reconstruction” of the image sequence, starting with the estimation of the Fundamental Matrix F, which is based on the existing projective correspondence between the epipolar lines. The epipolar lines are determined by the intersection on each image plane of the plane, which is determined by two cameras (their O centres) and an image point (Figure 3).

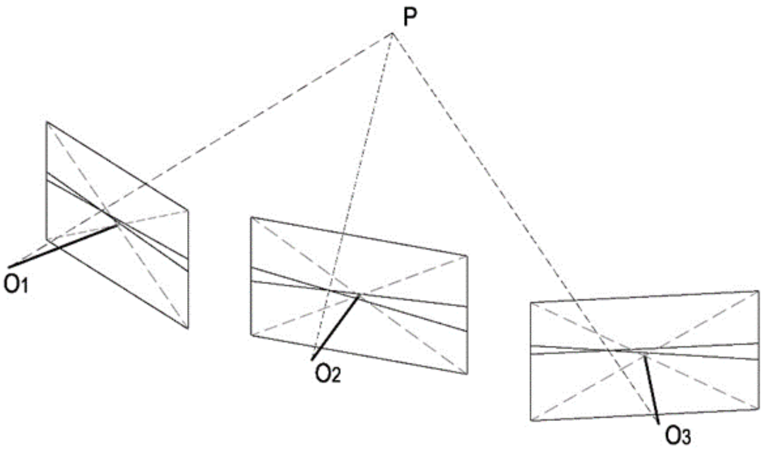

Figure 3. Three-frame “epipolar” lines.

Once you have a first estimate of the cameras, you continue with re-triangulation, which is carrying out the same process but with coordinates of the cameras already estimated a priori.

The integration of Photogrammetry with 3D Laser Scanner depends on the registration of the data of the two models, which constitutes its foundation. Manual registration will normally be necessary since individual models are created in different coordinate systems, and common points are problematic without pre-signalling.

We will talk here about several possible approaches:

- Photogrammetry aided by Laser Scanner (LS);
- LS with the help of photogrammetry;
- LS integrated with Photo Images;
- Integration into “object”.

To talk later about the 3D Modelling resulting from the integration of photogrammetry by SfM to obtain textures.

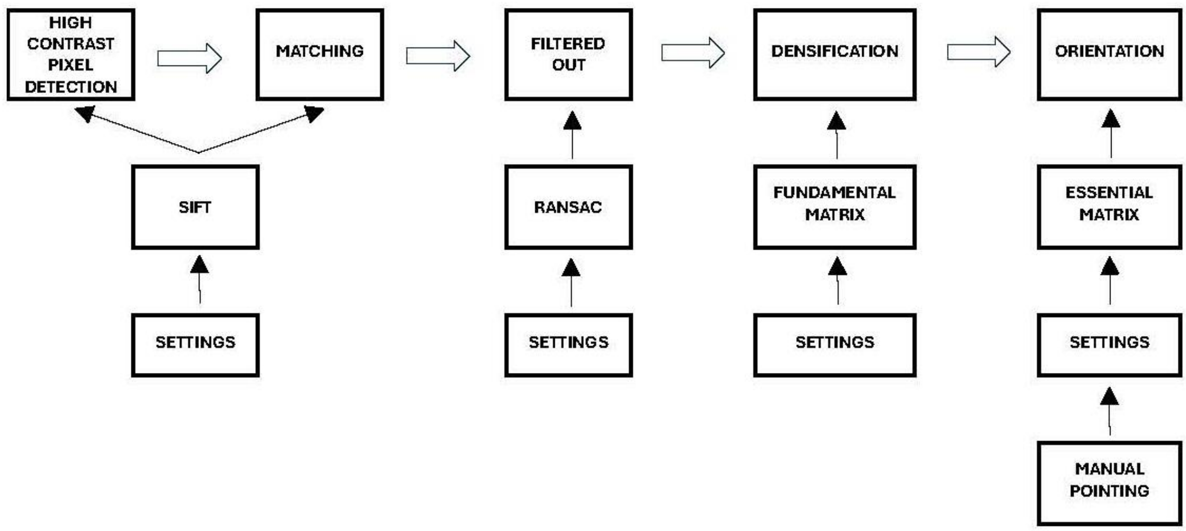

Figure 4. Basic scheme of the process of determining the structure of the model from the movement of the cameras (SfM).

In Photogrammetry helped by LS approach the principle is that the depth information is selected from the laser data, while the rest can be obtained from the images, so registration in a common coordinate system is essential.

Using laser scanning with the help of photogrammetry, the primary model is LS point clouds, although image data allows for texturing. The base model for co-registration is always the more reliable scan, while the more detailed LS mesh texturing is obtained from the images. This approach is useful for creating very detailed final models and is what we will use for the 3D survey of the Pantheon, the example that we will show, where the exterior of the Pantheon and its crypt appear.

With Object-Level Integration, LS (Laser Scanner) and photogrammetric, data are processed and interpreted separately so that integration occurs in the final stage. Orientation to the common coordinate system is usually done separately for LS and images. Although, if the object is small, it may be limited to the use of photogrammetric means, excluding LS. This will be the result of the last example. Well, Photogrammetry is only applied for 3D surveying and texturing. Subsequently, augmented reality will be applied to the result (AR is an interactive experience that improves the real world with perceptual information generated by computers. Using software, applications and hardware such as AR viewers, augmented reality is superimposed on digital content in environments and real-life objects).

2.2. Specific objectives. The rising of the Pantheons. Data collection

2.2.1. The Pantheon of the Cortina family

In the external survey of the Cortina Family pantheon, two teams have been used: a ground team as the main source of information and an aerial team as support to fill in information impossible to capture by the first, which caused serious security and safety problems schedules.

The ground equipment is made up of two professional cameras, with a tripod so that the shots are not out of focus, and a terrestrial laser scanner.

The aerial equipment formed by Drone F550, with 6 arms and 6 motors (at 960 kV) with a load capacity of up to 500 grams, had 3 batteries of 5200 mAh each, therefore, a flight time of 35 minutes.

For the interior survey on the stairs to the Crypt and inside the Crypt, the terrestrial laser scanner is used, making four parking lots, the first at the farthest point from the stairs, the second next to the stairs, and the third at the start of the stairs and the room at the end of the stairs, the latter could be joined to the exterior.

For the photogrammetric capture of the interior, a double photographic ring was made with displacements and a two-meter ladder to provide elevation and reduce the shadows of the laser scanner placed on the floor.

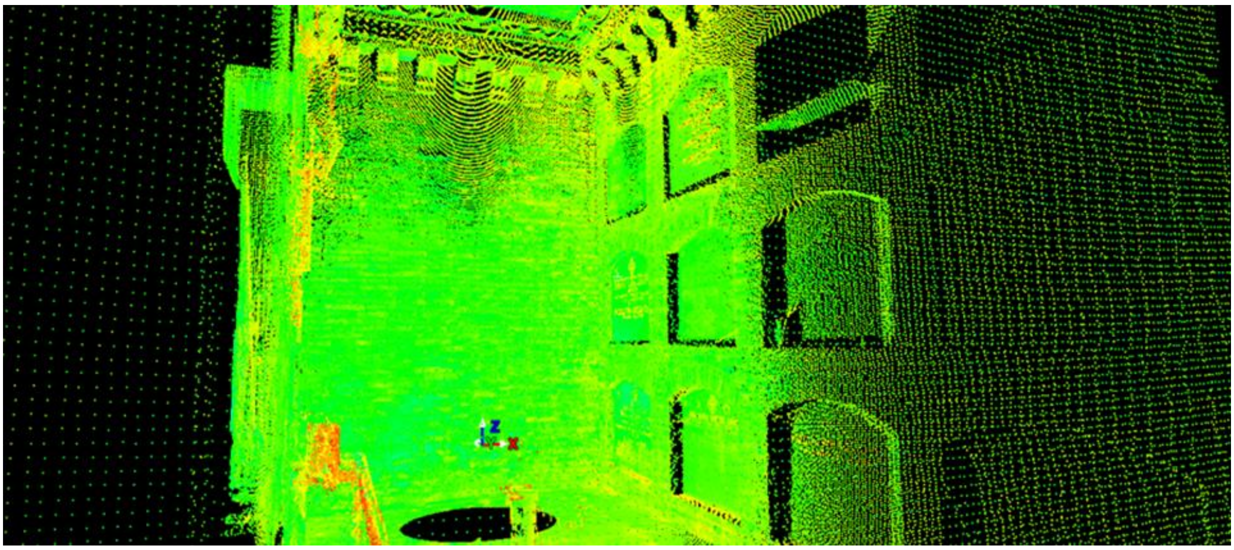

Figure 5. First scan of the Cortina family Pantheon

Figure 6. Exterior photographs of the Cortina family Pantheon

For the exterior survey, the photographic survey was carried out with a drone between 7:30 a.m. and 8:15 a.m. since the fundamental condition was that no one from the Cemeteries staff or visitors should be present during the flight.

Then, it started with the laser stations. The fifth parking lot (first exterior) was under the lintel of the door to join with the fourth station that had some exterior points; then, there were three more stations (all the parking lots were levelled), covering the entire Pantheon.

The exterior photogrammetric survey was carried out with the cameras and a ladder from the Cemetery itself that reached 3 meters plus the 1.5 m tripod, so a height of 4.50 m was reached. In Figures 6, 7 and 8, we can see the different photographic surveys.

Figure 7. Cortina family Pantheon exterior photographs and drones

Figure 8. Aerial exterior photographs (drone) of the Cortina family Pantheon

The camera settings for data collection and the way in which photographs are taken are also very important. A tripod is used, being necessary to avoid any movement and blur when taking the photograph. Close the lens to the maximum within the focus range to increase the level of detail. The ISO level and exposure will be constant, giving priority to the aperture since it is shot with the camera supported in order to obtain the best results.

Subsequently, the external point clouds were recorded and linked to obtain the result of Figure 9. The aerial point cloud was not very dense and was also located in another reference system and at another scale, which is why it was registered with respect to the data from the laser point cloud (Figure 10).

Once the orientation files of the hybrid model and the corresponding images with their orientation data with respect to the general reference system were obtained, both were imported into the Meshlab application to perform the texture mapping with the option of best matching of the normals of the mesh triangles.

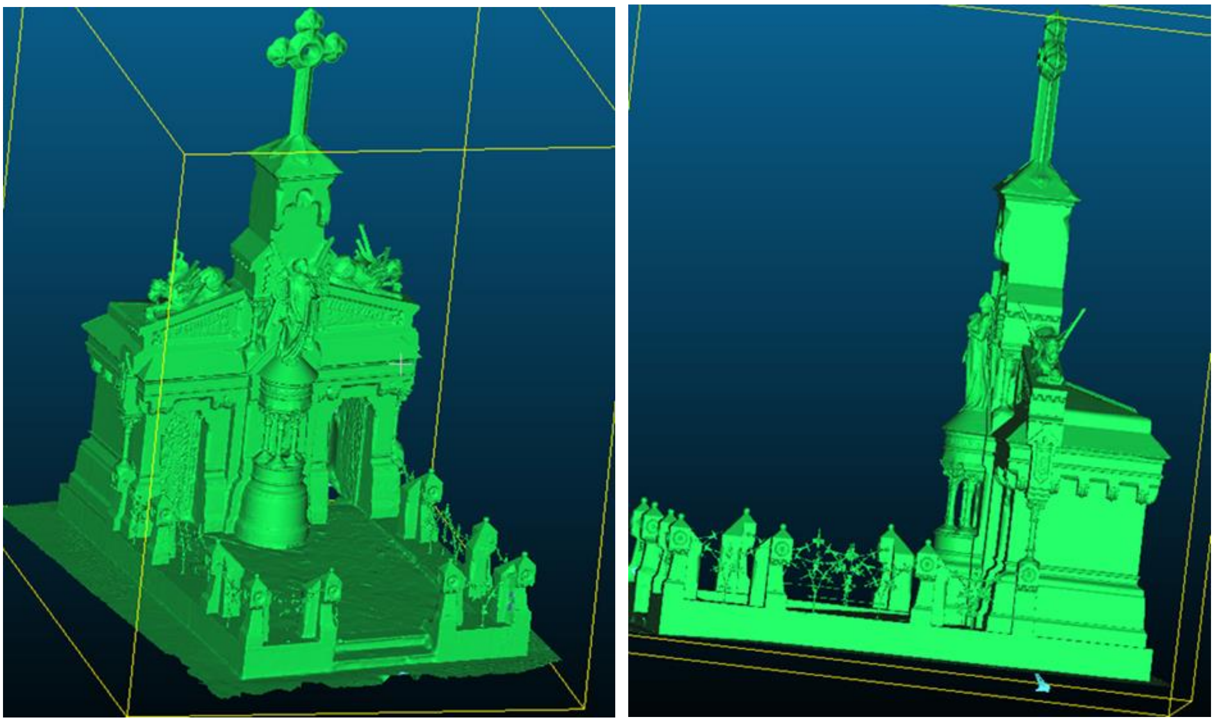

Figure 9. External point cloud of the Cortina family Pantheon

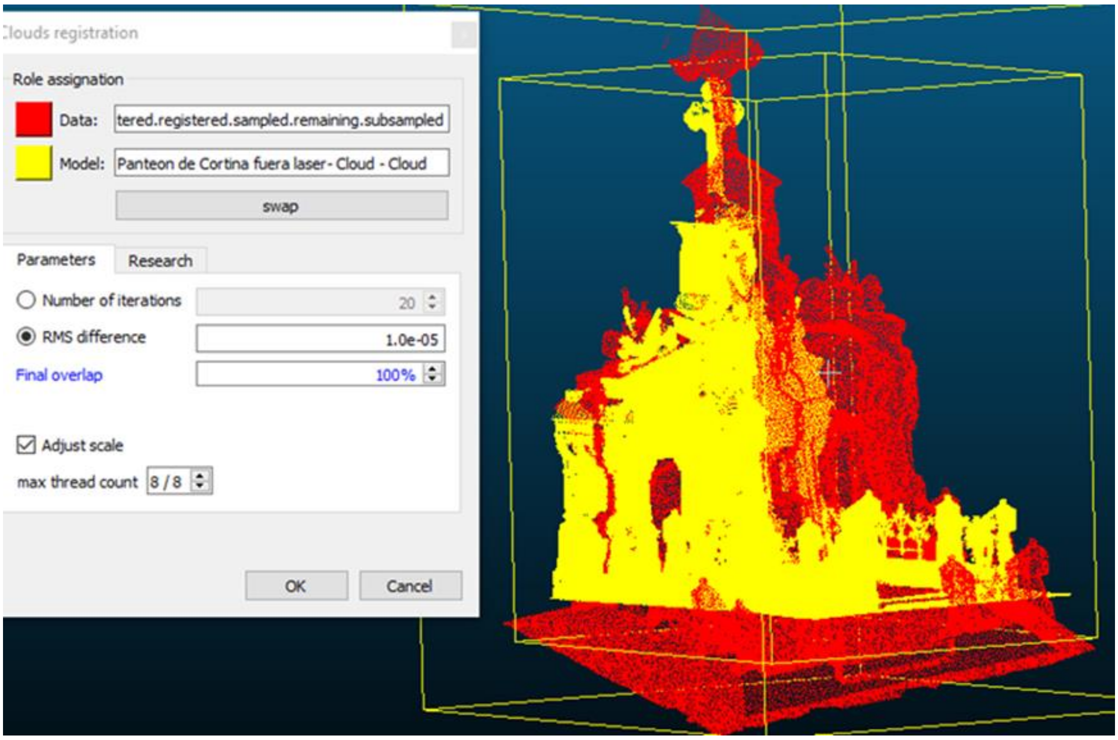

Figure 10. Registration of Cortina family pantheon aerial point cloud (in red) with the external laser one (yellow).

The only thing left to obtain the final model is to combine both models, exterior and crypt, into one. To do this, we load them into CloudCompare and using the merge option, we generate the final joint model.

The texturing of the Crypt in Figure 11 should not mislead us due to the transparency of the texture map (that is, seen from within the niches or inside the terrain) (Cabanes & Girbés, 2023; Franco, 2011).

Figure 11. Joint mapped and textured triangle mesh of the Cortina family Pantheon

2.2.2. The Morris Family Pantheon

As the object is small (1.70 meters high), the survey is limited to the use of photogrammetric means, excluding LS. Photoscan or any similar software can be used to obtain the textured mesh.

Later, we applied augmented reality to obtain a model appropriate to the final intention of this work (Figure 12), "The Museum of Silence", to obtain virtual models that allow the Pantheon to be viewed more completely. (Remondino et al., 2008; 2009).

Figure 12. Image of Augmented Reality applied to display the Morris Pantheon

With this Figure printed or on a rotating support, we can see the Pantheon from different points of view using a tablet that will give us information about each of the Pantheons that can be studied or exhibited (Figure 13). If we change the image, we can change the display from the outside of the Pantheon to its crypt (Ferdani et al., 2020).

Figure 13. Image of the Cemetery of Valencia where a Code is hidden to view the Pantheon.

3. Conclusions

We have seen that the objective of obtaining a 3D survey of our Pantheons is achievable with a low-cost methodology.

However, the main objective of incorporating these uprisings into the “Museum of Silence” in order to avoid looting in the General Cemetery of Valencia is not guaranteed.

In April 2016, the Valencia City Council launched two “Contests of Ideas for Rehabilitation in the General Cemetery of Valencia”. They stated: "We will improve and dignify facilities that are the city's heritage through the participation of external people and groups.".

But everything remained as good intentions; in the end, nothing was rehabilitated, the Museum of Silence was not built, and the looting continued.

Proof of this plundering, we have the following example and many more (Figure 14).

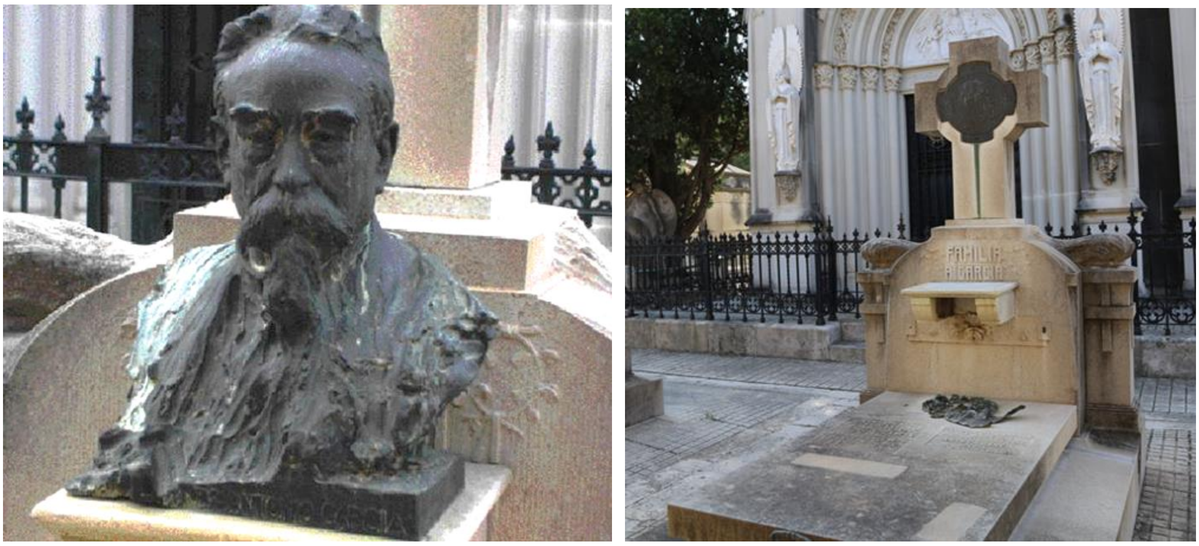

Figure 14. Pantheon of Antonio García Peris, before and after.

Result: a looted bronze bust that almost certainly ended up in a foundry and sold by weight.

The problem is the person represented in the bust, “a great character of the time”, Antonio García Peris (1841-1918), was a Valencian photographer who maintained one of the most active studios in the city of Valencia from 1862 until his death, in 1918—Father-in-law of Joaquin Sorolla y Bastida. The bust is by the master sculptor Mariano Benlliure Gil. The intention was that all these sculptures and elements, with great heritage value, would end up inside the Museum, and fibreglass copies would be placed outside. But it was late.

With this Museum of Silence, double value would be achieved:

- Promote Funeral Tourism, giving it artistic value.
- Promote the “Routes of Silence”, tourist tours that take place every 15 days in the General Cemetery.

The looting continues; what we mentioned above is a small sample. We must do something now.

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