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Graphic restitution of the Four Seasons Hall of the Marquis of Benicarló's House

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Abstract

The Marquis of Benicarló's House is one of the foremost examples of 18th-century civil architecture in the Valencian region. Within its walls, it safeguards ceramic panels from the esteemed Conde de Aranda Factory in Alcora, possessing significant historical and heritage worth.

However, akin to many other instances, before its designation as a Cultural Interest Property (BIC) in 2008, the structure underwent the removal of several architecturally valuable components, such as the flooring of the Four Seasons Hall. Thankfully, the original tiles from this flooring have been rediscovered within the collection of the National Museum of Ceramics and Decorative Arts González Martí.

This paper presents the graphical restoration efforts applied to the flooring, utilising the pieces sourced from the museum's collection. It also details the process of digitally restoring the flooring to its original location through advanced digitisation techniques. This enables the visualisation of the hall's authentic state using virtual reality methods, thereby facilitating its appreciation and dissemination as a heritage architectural space.

Keywords: *Marquis of Benicarló's House, ceramic flooring, architectural heritage, graphic restitution, virtual reality.*

1. Introduction

The Marquis House, also known as *Casa dels Miquels*, located in Benicarló, Castellón province, is a remarkable example of Valencian civil Baroque architecture. Erected in the late 18th century by Joaquín Miquel Lluís, it replaced the former Encomienda House, once the headquarters of the Commander of the Order of Montesa. The building comprises a ground floor, mezzanine, main floor, and attic, organised around a grand entrance hall (Figure 1) and gallery (García Lisón et al., 1983).

Figure 1. Entrance Hall and gallery. Marquis of Benicarló's House.

Notable features include a magnificent staircase, decorative ceramic coverings in the chapel and the kitchen, and decorative paintings and ceramic flooring in the noble rooms. The ceramics were crafted at the Conde de Aranda factory in Alcora (Gil-Saura, 2002; Pérez-Guillém, 1999). Designated as a singular BIC (Cultural Heritage) by the Valencian Government in 2007 (Consell de la Generalitat Valenciana, 2007) and definitively listed as such by the Ministry of Culture in 2008, it holds 1st category Real Estate with Monument status (Consell de la Generalitat Valenciana, 2007). A section of the original flooring of one of the main halls on the first floor has been replaced with modern white ceramic tiles, contrasting with the original perimeter tiles of different colours and sizes (Figure 2).

Figure 2. Hall of the main floor. Marquis of Benicarló's House.

Recovering this hall, including these decorative ceramics, presents a significant challenge, requiring the preservation of historical and stylistic authenticity while safeguarding their original properties and characteristics. Digital modelling techniques allow us to graphically restore these architectural elements in their original buildings and visualise and contextualise them using virtual reality (VR) techniques (Puyuelo-Cazorla et al., 2011).

2. Aims and objectives

The main objective of this work is the graphic restitution of this hall. To achieve this objective, the following aims have been proposed:

- Data collection of the hall using laser scanning and photogrammetry techniques;
- Generation of a point cloud of the hall;
- Meshing and texturing of the hall;
- Documentation of ceramic pieces;
- Graphic assembly of the ceramic pavement;
- Restitution of the pavement in the 3D model of the hall;
- Visualisation of the Hall using VR techniques.

3. Methods and procedure

Within the methodology, we must differentiate between the graphic survey work conducted within the building itself, the data collection performed in the museum, the graphic processing based on the initial information, the integration of the flooring within the digital model of the hall and its visualisation using VR techniques (Rodriguez-Navarro et al., 2022).

3.1. Data collection of the hall

Cutting-edge tools such as 3D scanners and photogrammetry systems are used for in-situ data capture in architectural research, enabling the creation of detailed 3D models without altering the physical structure (Guerra, 2029; Murcia-Soler et al., 2020). A Leica BLK360 3D Imaging Laser Scanner has been employed, featuring precise measurements and high-resolution imaging capabilities. Fieldwork involves planning the number of stations for scanning each floor and using Cyclone Field 360 software for real-time visualisation and alignment (Roldán-Medina et al., 2020). To collect data, the southeast area of the palace's main floor has been scanned, carrying out nine stations (Figure 3).

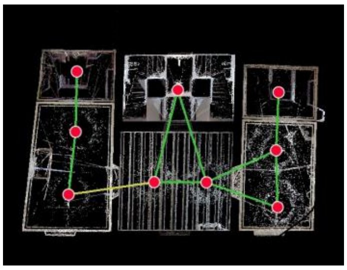

Figure 3. Site plan. Oriented point clouds of the floor.

Additionally, a photogrammetric model of the main floor has been created using a RICOH THETA Z1 360º photographic camera and MATTERPORT software. The resulting 3D model can be accessed online (Figure 4).

Figure 4. QR code of the 3D model of the building.

3.2. Generation of the point cloud

To process the point clouds acquired from the scanner, we utilised LEICA GEOSYSTEMS CYCLONE REGISTER 360 software. This software facilitated the recording and integration of the nine-point clouds by importing .blk files from the scan and aligning them to identify three common points in each cloud, resulting in a consolidated point cloud. Furthermore, the software offered capabilities for refining and orienting the point cloud.

Using this unified point cloud data, we generated a digital model of the southeast hall, the location of the original pavement.

To enhance the clarity of the point cloud, we employed the “smooth surfaces" tool, which effectively eliminated excess points, focusing solely on the walls and floor. Any unselected areas were highlighted in red and subsequently removed automatically (Figure 5).

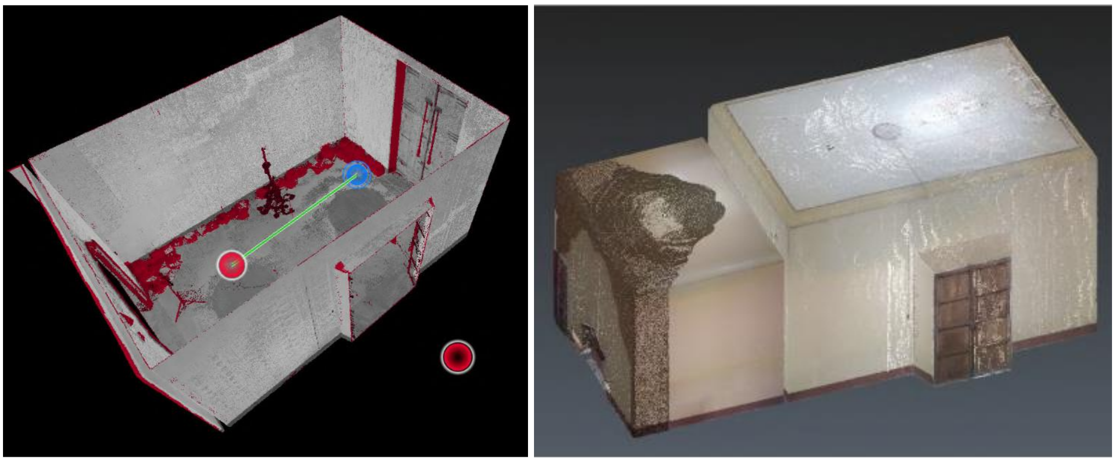

Figure 5. (a) Cleaning of the point cloud of the Hall. (b) Colourpoint cloud of the Hall.

3.3. Meshing and texturing of the hall

The point cloud has been imported into the Cyclone 3DR program in an e.57 format to create the mesh. Then, the "3D mesh creation" tool was selected, and the "two-step meshing" option was chosen (Figure 6).

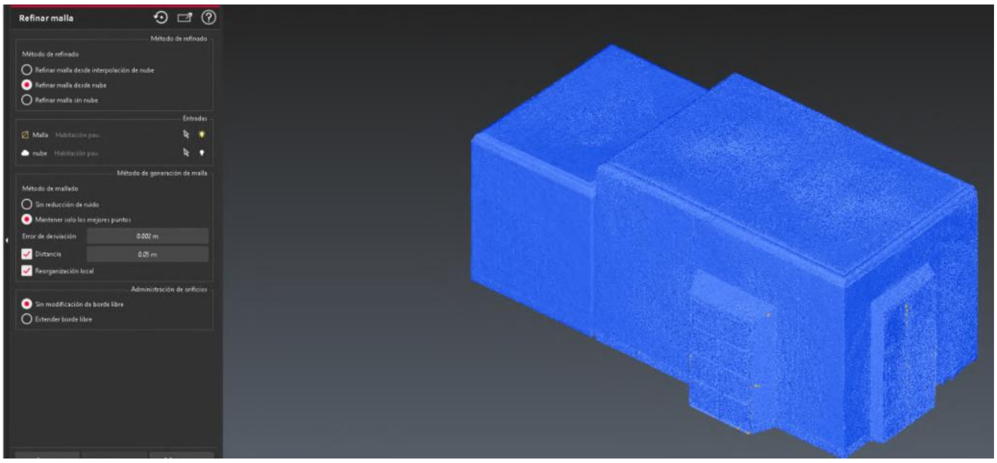

Figure 6. 3D mesh unrefined

The next step has been to select "refine mesh from the cloud." From this process, a mesh of the Hall has been obtained. The next step has been to improve the mesh for subsequent texturing.

Afterwards, the "global smoothing" tool was used, and the "smooth noise" tool was selected, thus achieving a more homogeneous model. However, several errors in the mesh still need to be corrected using different modelling tools.

Using the "clean/separate," "bridge," "fill holes," and "smooth mesh" tools, all poorly modelled parts have been eliminated, and the mesh has been adjusted. To delineate each part of the room for subsequently applying each texture in its correct place, a polyline has been created on each one of the edges, its projection onto the mesh has been performed, a constrained mesh has been created, and subsequently, the "sharp edges" tool has been applied (Figure 7).

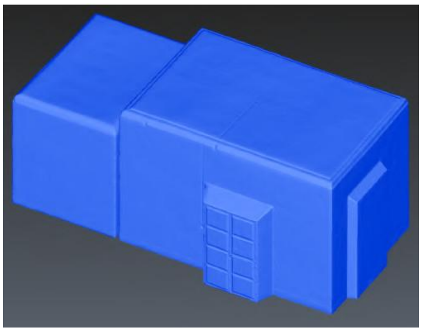

Figure 7. Tight and refined mesh

With the GIMP software, the three spherical images captured by the scanner itself have been edited to texture the room. The main edits focus on fixing the lights generated on the walls and ceiling, removing the stacked tiles on one side of the hall, and eliminating the bed's headboard (Figure 8).

Figure 8. (a) Original spherical image of the Hall. (b) Edited spherical image of the Hall.

The adjusted and refined mesh has been textured using different spherical images of the room once edited. With this procedure, a fully textured mesh of the room has been obtained (Figure 9).

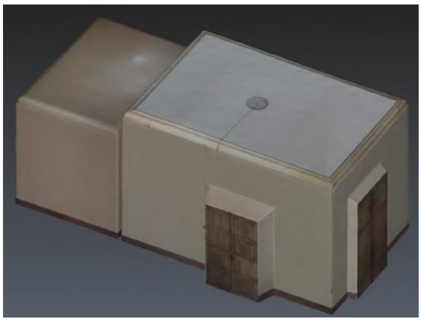

Figure 9. Mesh textured using spherical images.

3.4. Documentación of ceramic tiles

To capture photographs of the ceramic tiles, we utilised Nikon D-80 and Nikon 5200 cameras equipped with conventional lenses (18-135 mm, f/3.5-5.6 aperture) as well as a Sigma wide-angle lens (8-16 mm, f/4.5-5.6 aperture). These cameras were securely mounted on an adjustable support system to ensure precise focus and alignment of orthogonal images. The tiles were positioned on a millimetre template to facilitate accurate adjustments.

To minimise any potential lens movements, remote triggers via the SnapBridge application were employed (Figure 10). Each tile was photographed from both the obverse and reverse sides, and additional data collection included weighing and measuring each piece using a calliper.

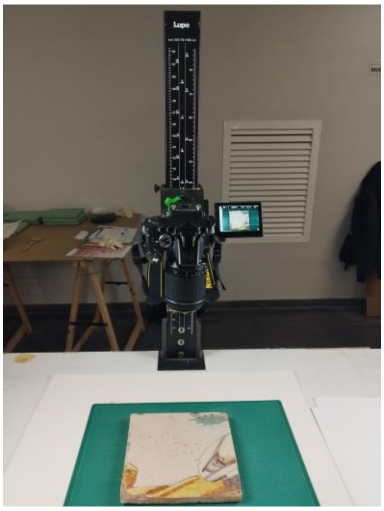

Figure 10. Capture of images of the ceramic pieces.

3.5. Graphic assembly of the ceramic pavement

In this subsection, the graphic process carried out based on the images captured of the ceramic pieces located in the museum will be presented.

The tiles were labelled and numbered based on the initials of each set, following the methodology outlined in the graphic restoration work of the Sanjoans Palace (Julián-Querol, 2010). To correct fisheye lens distortion, also known as "barrel distortion", the images underwent rectification using PTLENS software. This rectification process was generally effective, especially considering the capture conditions with orthogonal support to the pieces. However, in instances where warping occurred, further rectification was conducted using ASRix software. Once rectified, the images were cropped to eliminate the background using the GIMP photographic retouching tool.

Subsequently, the cleaned and retouched images were assembled into different decorative panels using GIMP software on a 21.5 x 21.5 cm grid. Each subset represented a different pattern, such as Spring, Summer, Autumn, Winter, Chronos, corner border, brown border, blue border, and white panel. The Four Season panels consisted of 16 tiles, the Chronos panel of 44 pieces, and the border and white panels of 9 tiles each (Figure 11).

Figure 11. Digital reconstruction of the Winter ceramic panel.

After obtaining the individual patterns, a grid of 33 x 21 tiles was constructed, each containing a distinct decorative pattern. The panel was then finalised by incorporating a segment composed of undecorated white pieces.

Subsequently, the edited photographs were applied to the mesh using the "texture from image" tool. However, due to inadequate software adjustment, manually adjusting each room area with the desired photograph was necessary, accomplished through the "texture adjustment" tool (Figure 12).

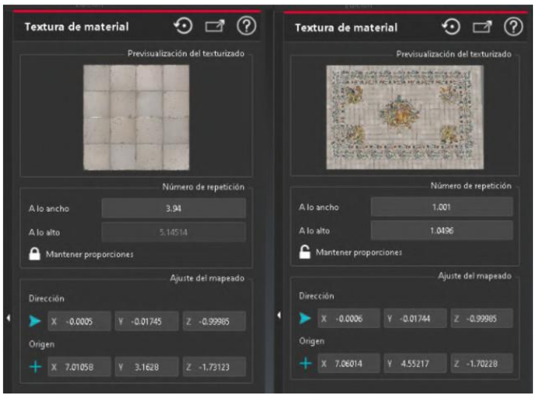

Figure 12. "Texture adjustment" tool.

3.6. Restitution of the pavement in the 3D model of the hall

Two textures were created from scratch for the flooring creation: one depicting the fully decorated flooring for the main room and another one featuring a module of 4 x 4 white tiles for the adjacent room.

To facilitate the flooring placement, the flooring has been divided into two parts and separated from the rest of the room, leaving a mesh of the walls and ceiling, one mesh on one floor and another on the other. Each texture has been applied separately by importing each image into the program, and using the "texture adjustment" tool, both textures have been applied; by adjusting the values of each image, we position the photos in their place.

By adjusting the values of each image, the images have been placed in their correct positions. The final result can be observed in Figures 13 and 14.

Figure 13. Pavement texture adjusted to the mesh. Floor view.

Figure 14. Pavement texture adjusted to the mesh. 3D view.

3.7. Visualisation of the Hall using VR techniques

To upload the model to the Sketchfab platform, the .obj file size has been reduced using MeshLab software as follows: Filters -> Remeshing, Simplification, and Reconstruction -> Simplification: Quadric Edge Collapse Decimation (with texture) -> Target number of faces 500,000.

The model has been uploaded to the Sketchfab platform, where it is possible to perform a 3D visualisation of the model and navigate through it (Figure 15).

Figure 15. QR code of the 3D model at Sketchfab web.

4. Results

The efforts have created a comprehensive digital model of the room, allowing for in-depth exploration from historical and heritage viewpoints and facilitating its cultural dissemination in a virtual environment. This digital model provides a visualisation of the architectural space as it existed before the removal of the decorated ceramic pavement, thereby enriching our understanding and appreciation of the space (Figure 16).

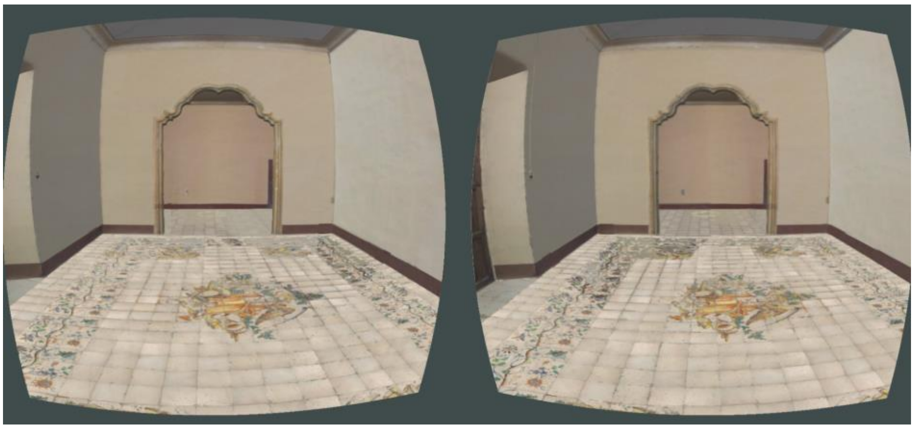

Figure 16. Visualisation of the Hall through VR.

5. Conclusions

Virtual Reality (VR) offers significant advantages in preserving architectural heritage that may be threatened, destroyed, or difficult to access. By creating virtual models of historical buildings, VR enables digital documentation and preservation, ensuring these monuments can be experienced and appreciated by current and future generations. This approach safeguards cultural heritage and facilitates its global dissemination, overcoming physical and geographical limitations.

VR has emerged as a groundbreaking tool for visualising architectural heritage, providing various benefits from sensory immersion to digital preservation. Its capacity to recreate historical environments, promote interactivity, and grant global access to cultural treasures positions it as a potent tool for conserving and disseminating architectural heritage.

The Marquis of Benicarló's House stands among the four unique Cultural Interest Properties (BICs) in Benicarló today, boasting significant heritage and historical value. It holds immense potential as a cultural landmark within the province of Castellón, particularly in the region of Bajo Maestrazgo.

Through digital modelling and VR technology, we've been able to digitally restore the splendour of one of its distinctive architectural spaces, named the "Four Seasons Hall." Utilising this technique, we've created an immersive journey back to the late 18th century, offering a glimpse of this space in its original conception (Figure 17). This methodology holds promise for similar case studies, providing a means to restore damaged or missing architectural elements.

Figure 17. View of the flooring in the 3D model of the Hall.

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