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VIRTUAL RESTITUTION IN THE SERVICE OF LOST HERITAGE. THE CASE OF THE VALLADOLID COLLEGIATE CHURCH/CATHEDRAL OF SANTA MARÍA LA MAYOR

LA RESTITUCIÓN VIRTUAL AL SERVICIO DEL PATRIMONIO DESAPARECIDO. EL CASO DE LA COLEGIATA/CATEDRAL DE SANTA MARÍA LA MAYOR DE VALLADOLID

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Highlights:

- The virtual restitution of the Valladolid Collegiate Church reconstructs its architecture and memory, bringing new life to a lost heritage through graphic technology and historical research.
- The use of engines, such as Unreal Engine and Twinmotion, enables hyper realistic visualisations, optimising time and facilitating immersive, real-time experiences.
- The interactive virtual tour offers a free and educational exploration of the temple, integrating 360° images and hotspots with enriched multimedia content.

Abstract:

This article presents a virtual restitution of the interior of the Santa María la Mayor Collegiate Church in Valladolid, a Gothic temple with Romanesque features that was dismantled between the 17th and 18th centuries. Through interdisciplinary research combining historical documentation, architectural analysis and digital modelling, the study recovers the spatial and artistic essence of the original building, giving it a new graphic life. The methodology falls within the scope of virtual archaeology, understood as a scientific discipline that uses digital technologies to rebuild, analyse and highlight lost heritage. In this case, the restitution is based on the study of preserved architectural remains, documentary sources and comparisons with contemporary temples, generating formal hypotheses that can be verified through three-dimensional (3D) representation. Using real-time visualisation engines, such as Unreal Engine and Twinmotion, and applying physically based rendering (PBR) textures, a high-fidelity visualisation has been achieved that accurately reproduces the temple's materiality, lighting and interior atmosphere. These tools, typically used in interactive design and video games, allow visitors to explore the space in real time and experiment with different lighting, colour and texture conditions, contributing to a more complete understanding of the monument. The process culminates by creating a dynamic video rendering and an immersive 360º virtual tour, structured around interactive points that offer textual, graphic and audiovisual information. These results allow architectural hypotheses to be tested and lost structures to be visualised; in addition, they also promote cultural dissemination, public participation and the creation of new paths to access heritage knowledge. This project thus exemplifies the potential virtual archaeology has as a tool for research, conservation and communication of lost architectural heritage.

Keywords: Valladolid; cathedral; lost heritage; virtual restitution; virtual tour

Resumen:

Este artículo presenta una restitución virtual del interior de la Colegiata de Santa María la Mayor de Valladolid, un templo gótico con rasgos románicos que fue desmontado entre los siglos XVII y XVIII. A través de una investigación interdisciplinar que combina documentación histórica, análisis arquitectónico y modelado digital, el estudio recupera la esencia espacial y artística del edificio original, devolviéndole una nueva vida gráfica. La metodología se enmarca dentro de la arqueología virtual, entendida como una disciplina científica que utiliza tecnologías digitales para restituir, analizar y poner en valor el patrimonio desaparecido. En este caso, la restitución parte del estudio de los restos arquitectónicos conservados, fuentes documentales y comparaciones con templos coetáneos, generando hipótesis formales verificables mediante representación tridimensional. Usando motores de visualización en tiempo real, como Unreal Engine y Twinmotion, y con la aplicación de texturas PBR ('*Physically Based Rendering*'), se ha logrado una visualización de alta fidelidad que reproduce con precisión la materialidad, la iluminación y la atmósfera interior del templo. Estas herramientas, procedentes del ámbito del diseño interactivo y del videojuego, permiten explorar el espacio en tiempo real y experimentar con diferentes condiciones de luz, color y textura, contribuyendo a una comprensión más completa del monumento. El proceso culmina con la elaboración de un videorrenderizado dinámico y una visita virtual inmersiva en 360º, estructurada mediante

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puntos interactivos que ofrecen información textual, gráfica y audiovisual. Estos resultados permiten contrastar hipótesis arquitectónicas y visualizar estructuras perdidas; además, también favorecen la divulgación cultural, la participación pública y la creación de nuevas vías de acceso al conocimiento patrimonial. Este proyecto ejemplifica así el potencial de la arqueología virtual como herramienta de investigación, conservación y comunicación del patrimonio arquitectónico desaparecido.

Palabras clave: Valladolid; catedral; patrimonio desaparecido; restitución virtual; visita virtual

1. Introduction

Advances in computer technology are facilitating the achievement of three-dimensional (3D) representations of lost architectural heritage. In addition to the technical knowledge required to use these software tools, interdisciplinary collaboration is essential for the development of graphic works that help visualise the buildings under study (Fernández Ruíz et al, 2013; Valle Abad et al, 2022). Art historians, archaeologists, architects, public institution technicians, and other professionals are collaborating to make possible the virtual restoration of lost buildings, thereby giving them a new graphic life (Viscogliosi et al, 2006; Borghini et al, 2011). Professor Ortega Vidal has mentioned that buildings have three lives (Ortega Vidal et al, 2011: 51). The first is the *physical or material life*, when the building is in use and people can use and experience it. The second is the *cultural or mental life*, when the building no longer exists but is still remembered by the people who saw or used it. And finally, the third is the *graphic life*, when the building is no longer there, and neither are the people who knew it. This is where drawing, whether manual or virtual (Cáceres-Criado et al, 2022), has the greatest potential to enhance the memory of the monument or the urban scene that is no longer before us[1].

The aim of this work is to architecturally analyse the different elements that formed the interior of the Collegiate Church of Valladolid, verifying the hypotheses adopted through its virtual restoration (Di Mascio et al, 2016; Aparicio Resco, 2021; Bianconi et al, 2023). Its architectural remains still reflect the monumentality of this temple, which, due to the ruin caused by various historical events, presents a distorted image that this work aims to recover.

Likewise, the technical process of this work is analysed, as well as the details of the various virtual restoration technologies currently available in a constantly evolving market that allow for optimised modelling and rendering results (Remondino et al, 2014).

2. El object of study: The Collegiate Church of Valladolid

Although a Romanesque Collegiate church was built at the end of the 11th century, at the time of the founding of the city of Valladolid, it soon became too small for the growing town, and it was expanded in the first third of the 13th century. The resulting church is the subject of this study (Gimeno Sanz et al, 2023: 159).

The Santa María la Mayor Collegiate Church was used as a Cathedral until 1668, when worship was moved to the new, unfinished Renaissance-style church designed by the famous architect Juan de Herrera, author of such emblematic works as the Royal Monastery of *San Lorenzo de El Escorial*. The dismantling of the Gothic church began in 1688 and was still ongoing in 1782. Nowadays, its ruins remain next to the Renaissance cathedral, presenting a distorted image of its past existence (Fig. 1b).

Part of the perimeter walls is preserved up to the eaves. These remains include some doors, windows, attached pilasters, and the beginnings of the arches that once covered the building. At the end of the 20th century, cypress trees were planted in the location where the central pilasters once stood (Fig. 2a). As can be seen in Figure 1b, the three apses have been drawn using the hedge and the railing that enclose the space.

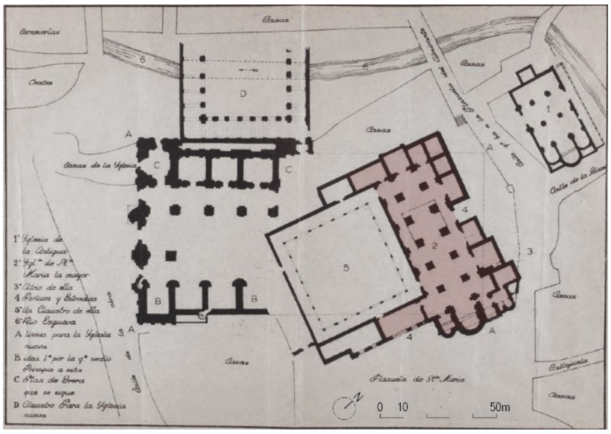
The church followed Gothic architectural standards, with marked Romanesque features. It was composed of three naves, the central one being wider and of similar height to the side naves. It was a longitudinal space with five sections and a transept. At the foot of the church stood a bell tower that is still preserved today, albeit with modifications. The Gospel side of the church had side chapels, as was the case on the opposite side, although they were limited in size due to the annexed cloister next to the collegiate church, which formed part of the religious complex (Fig. 1a). The head of the church was topped with three ultra-semicircular apses. The entire building was covered with a Mudejar coffered ceiling, which was completely destroyed when the church was dismantled to be moved to the new location of the Cathedral.

The temple was accessed through the side door, reached by ascending a flight of steps, and through the "Lion Portico," next to the apse on the Epistle side. This space, so named because it features a column crowned by a lion, was conceived as a covered atrium prior to the temple, as it faced the *Plaza de Santa María*, a bustling and active market area (Fig. 3a).

The interior of the church would have been quite dark because it was only lit by the openings in the side chapels, as the central nave was no higher than the side chapels, which prevented the use of windows, as is usual in this type of church. The apses would also have had narrow Romanesque-style windows. It is understood that due to the lack of natural lighting, the interior would have relied on artificial lighting from candles and lamps both day and night.

The side chapels would have been closed with wooden bars that have not survived to this day. The two side chapels of the presbytery had iron bars that were transferred to the new Cathedral, where they are preserved, documented, and modelled for their virtual restoration. The same would happen with the burial of the city's founder, *Don Pedro Ansúrez*, whose tomb, formerly located in the left arm of the transept, was moved to the current Cathedral (Fig. 3b).

[1] The work of López Bragado et al (2021) serves as an example of this type of graphic methodology that combines rendered images with video rendering with a more dynamic description.



(a)

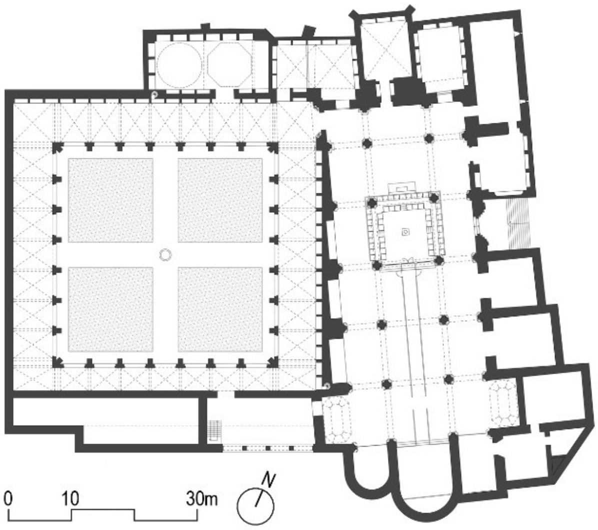
(b)

Figure 1: a) Plan of the three cathedrals (modern copy of a late 16th century original. The Collegiate Church in red); b) The Cathedral of Valladolid and the ruins of the medieval Collegiate Church.

The main chapel of the temple was presided over by a magnificent altarpiece that, after its transfer, was sold to the neighbouring town of Renedo, which, over time, was resold to the parish of Amusquillo, where it remains and has been documented for the completion of this work. Likewise, this main chapel was adorned with red velvet hangings embroidered in gold, which were also sold to various buyers, some of which remain in the *Château de Chambord*, in the apartments of the French king Francis I (Fig. 4a).

The chapter choir, used by the Cathedral canons to follow the liturgical services, was located in the centre of the church. It was situated in the third section of the central nave, opposite the side entrance to the church. It was enclosed on three sides and opened onto the presbytery. It had two levels: the lower one consisting of 20 seats and the upper one with 27. Some of these seats are scattered throughout different rooms of the current Cathedral, which has served to graphically document them for their restoration (Fig. 4b). Once again, the front of this choir enclosure was closed with a wooden grille that has not been preserved. Both this enclosure and that of the side chapels were modelled after other examples from the Kingdom of Castile from the same period.

(a)



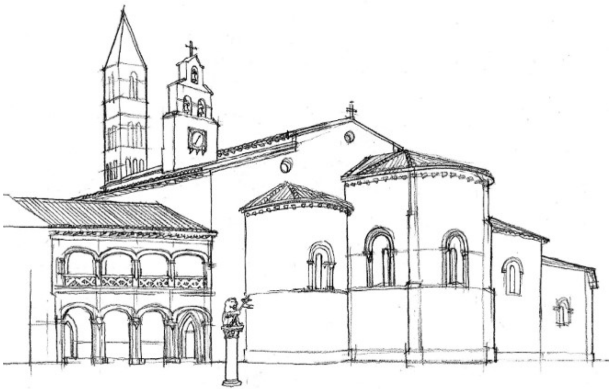
(b)

Figure 2: a) Current state of the ruins of the Collegiate Church; b) Plan ot the Collegiate Church (Urrea, 2021: 18).

Between the choir and the main chapel, there was a "sacred path", or processional route, separated from the rest of the space by iron railings. Some of these barriers were transferred to the new Cathedral, adapted as railings for some of its staircases.

3. Scientific traceability and evidence scale

The initial phase of the work consisted of historical and documentary research, an iterative process of compiling, analysing, and comparing primary and secondary sources. The documentary corpus included archival documentation and historical texts, historical plans and old drawings, specialised historiographical studies (Urrea, 2021; Gimeno Sanz et al, 2023), as well as on-site analysis of photographs and topographical surveys of the architectural elements preserved in the current Cathedral. A comparative analysis was carried out with contemporary Gothic temples in the Castilian area to corroborate the structural typology, liturgical hierarchies, and original formal characteristics. This data collection allowed for the formulation of verifiable geometric hypotheses (Table 1).



(a)

(b)

Figure 3: a) Graphic restitution of the head of the Collegiate Church and the Lion Portico (Santiago Bellido, in Urrea, 2021: 21); b) Tomb of Count Ansúrez in the new Cathedral.

(a)

(b)

Figure 4: a) Hangings of the main chapel in the castle of Chambord (Jesús Urrea); b) Main stall and chairs of the resto f the choir preserved in the Cathedral.

Various architectural and non-architectural elements, such as furniture or liturgical objects, are involved in any graphic restitution, and these do not necessarily present the same degree of certainty. It is crucial that each modelling decision be classified according to its level of evidence (documented, inferred, or hypothetical) in order to maintain epistemological clarity about the degree of certainty of the representation (Demetrescu et al, 2020). One of the key points in formulating a virtual hypothesis is the visualisation of these results (Mizrahy-Cuperschmid et al, 2024; Llopis Verdú et al, 2024). Therefore, in addition to Table 1, a graphical analysis was performed using a scale of levels of evidence applied to each of the constructive elements represented (Figure 5). This ensures the historical and archaeological rigour of the research, while providing additional information to the scientific community for their knowledge, validation, or possible refutation.

As can be seen, the elements preserved in the ruins have been marked in red, as well as, in particular, the railings and altarpieces that were moved to the interior of the Cathedral or to other churches. A second level of certainty includes elements that have been partially preserved or have undergone modifications, including the general structure of the church, the rich hangings of the presbytery, the Via Sacra, and the choir stalls.

Table 1. Levels of evidence in virtual restitution.

Level of evidence	*Description*	*Applied criteria*	*Examples in the reconstruction*
Direct evidence (Documented / certain)	Elements whose form, proportion, and location are demonstrated by primary sources or preserved physical remains.	- Partial or total material conservation - Verifiable historical graphic records - Precise documentary sources	- Plan and structural rhythm defined by preserved pilasters - Location of Ansúrez's tomb - Grilles transferred to the current Cathedral
Indirect evidence (Inferred / probable)	Elements that are not preserved in their entirety, but whose form can be deduced from consistent material or documentary evidence.	- Partial vestiges or architectural traces - Incomplete textual or graphic references - Typological correspondence with verified coeval buildings	- Section and proportions of the naves - Typology and arrangement of the Mudejar roof - Design of the choir based on original pieces and analogous references
Substantiated hypothesis (Plausible restitution)	Elements neither preserved nor directly described, reconstructed with scientific criteria based on historical, typological, and constructive analogy.	- Comparative analysis with Castilian Gothic temples - Structural and stylistic coherence - Explicit archaeological and architectural justification	- Secondary decoration of the choir - Organs reconstructed according to documented models in Lerma and Salamanca - Details of carpentry and polychromy

The walls that delimited the choir have been incorporated at a third level. The altarpiece located behind the choir has been represented in blue, for which a textual description is available, allowing for its restoration. Purple indicates elements whose existence is documented but whose exact form is unknown, for which other contemporary examples have been used. This is the case of the choir grille, the railing, and the organs located in the upper part of the choir. Also included in this level of certainty are the grilles of the side chapels and the wooden coffered ceiling of the collegiate church.

Finally, the floor of the temple and the steps of the presbytery are shown in grey, which would have been filled with individual burials, as was customary at the time.

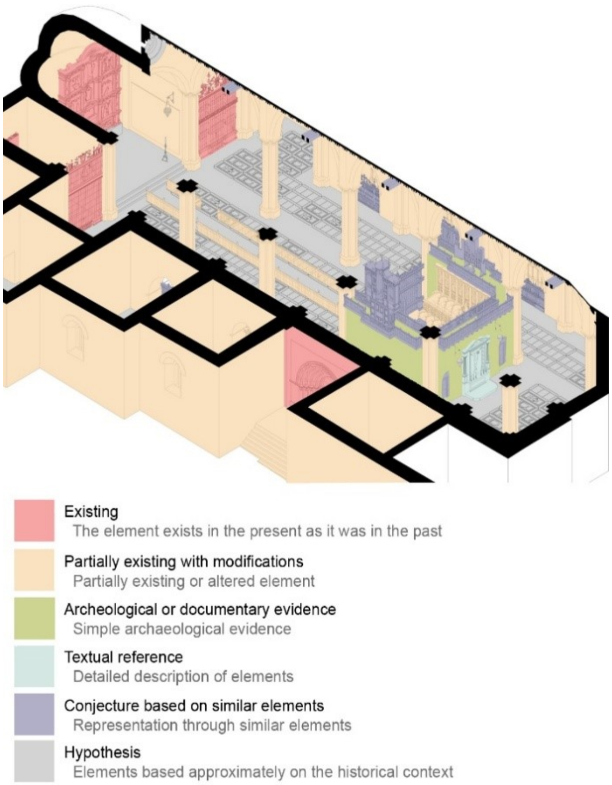
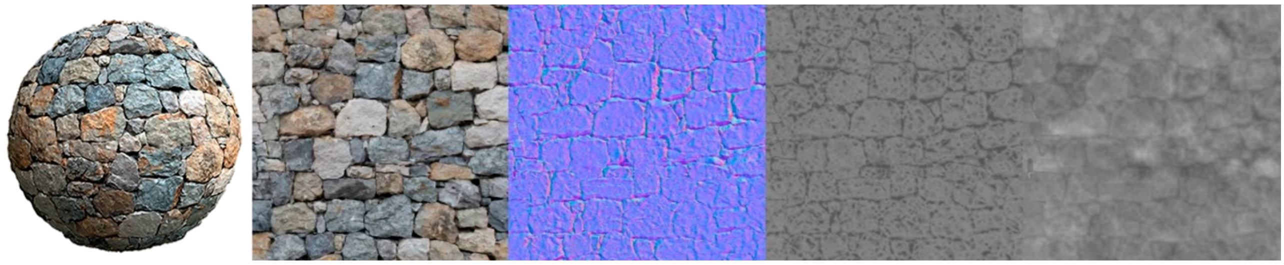


Figure 5: Scientific traceability of virtual restitution.

4. Virtual restitution methodology

The virtual restitution of the Santa María la Mayor Collegiate Church was carried out using a systematic and traceable workflow, based strictly on historical evidence. This process coherently integrates critical documentary analysis, parametric digital modelling, the application of rendering texturing, and the use of real-time visualisation technologies. The methodology implemented strictly adheres to the principles of the London Charter and the Seville Principles, ensuring transparency, scientific traceability, and critical rigour in the digital reconstruction of the heritage object.



(a) (b) (c) (d) (e)

Figure 6: PBR materials are the result of layering multiple textures: a) PBR Material; b) Base Colour; c) Normal Map; d) Roughness Map; and e) Height Map.

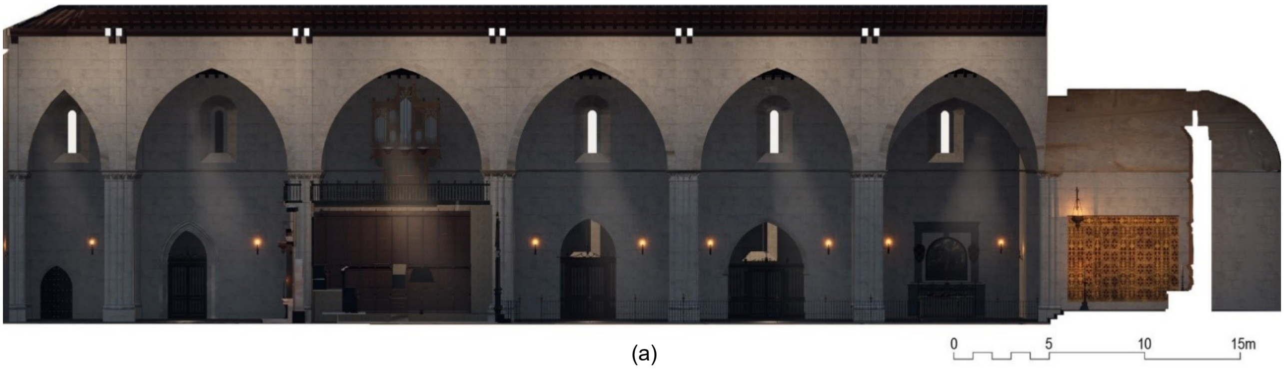
Figure 7: SketchUp screenshot with colour assignment by surface for each material (own creation).

The 3D geometric modelling was carried out in a CAD environment using AutoCAD 2023 and SketchUp 2021, following strict scientific restoration criteria (Guerrero Vega et al, 2023). The structural grid was drawn, followed by the volumetric definition of naves, sections, walls, pilasters, arches, roofs, and apse facings. The reconstruction of the choir, the railing, and the liturgical furniture was carried out using preserved pieces as a reference and digitally incorporating transferred elements (the tomb of Ansúrez, the railings, and the choir stalls). Materials of different colours were applied to each of the 3D elements according to the materiality of the object, which will subsequently facilitate the application of the real materials in the final rendering program (Fig. 7).

Figure 8: Application of materials to each of the elements that define the building objects.

In the specific case of studying the interior spatiality of the Santa María la Mayor Collegiate Church, the objective was to experiment with new visualisation tools that are widely used today in the field of video games and cinema (Ferdani et al, 2020b; Soto-Martín et al, 2020). These new visualisation tools are game engines. These usually include a graphics engine and a physics engine, but the biggest advantage of these programs is that they allow real-time visualisation of the scene, showing the final texture and lighting of the 3D model (Pàmies et al, 2023). In addition, rendering the final image takes only a few minutes. This reduction in processing time is due to the use of PBR (Physically Based Rendering) materials, a real-time shading and rendering system that provides an accurate representation of how light interacts with a surface (Fig. 6).

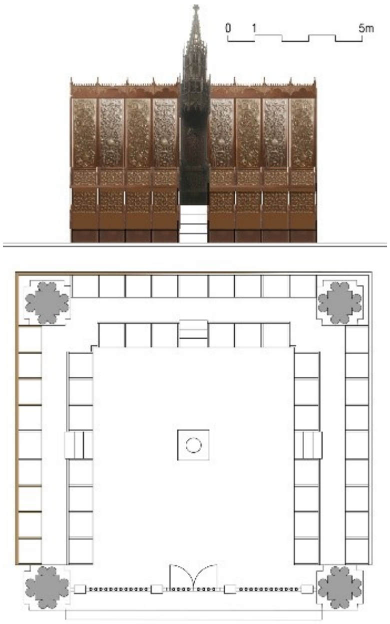
Figure 9: Example of application of the materials and the final textured result.



(a)

(b)

Figure 10: a) Longitudinal section through the center of the nave; b) Cross section through the transept (on the right is the Lion's Porch).



(a)

(b)

Figure 11: a) Plan of the chapter choir; b) Top view of the choir with the organs.

The main objective of this test is to demonstrate the potential of Unreal Engine 5 in the field of architectural representation, not only in the generation of high-quality static images, but especially in the creation of dynamic sequences through virtual tours. This type of immersive visualisation offers a more complete and accessible spatial experience, facilitating the understanding of the architectural project for both professionals and the general public. In short, this application of Unreal Engine in the context of heritage visualisation allows us to explore new possibilities for the dissemination and communication of architectural heritage through advanced digital technologies (Rua et al, 2011).

The problem is that, as it is a program focused on video game development, the working environment is quite complex and requires programming knowledge, which makes it difficult to use. For this reason, we opted to use other software with a simpler working environment, but also based on the Unreal rendering engine: Twinmotion v. 2022.1. The workflow we ultimately followed was as follows:

- Import the 3D model of the object you want to work with.
- Once the import is complete, the next step is to configure the lighting, both global or natural (sun) and artificial (spotlights). This step increases the number of calculations because when displaying the image in real time, each time you move around the object, the interaction of light rays with its surfaces is recalculated. This process, known as ray tracing, allows you to realistically calculate the reflections and shadows generated by the ambient lighting (Fig. 9)[2].
- Then apply the materials. To do this, you must first identify each surface with the same material in an external program (in this case, SketchUp) and apply a specific colour to each material (Fig. 8). The textures used are PBR, which are essential in the world of rendering, as their main objective is to achieve visual realism by accurately simulating how light interacts with the surfaces of objects[3].
- Finally, the cameras were placed in the positions from which a static image was desired. Normal cameras (which produce a flat image from a single point of view) or spherical or equirectangular panoramas (which enable virtual tours by allowing you to see 360° around the point of view) were used.

This methodological process, using various digital tools, resulted in a functional virtual model that, in addition to serving as an analytical tool, allows the generation of images, animated sequences, and an immersive virtual tour accessible to the public, aimed at promoting heritage (Table 2).

Table 2. Software and Tools Used

Phase	*Software / Tools*	*Function*
Documentary analysis	Digital bibliography, historical repositories	Collection of primary and secondary sources
Base 3D modelling	AutoCAD / SketchUp 2021	Geometric reconstruction of the building
UV mapping	SketchUp 2021	Precise assignment of surfaces for texturing
Texturing	Commercial and proprietary PBR materials	Physically based material representation
Visualization engine	Twinmotion 2022.1 (Unreal Engine base)	Real-time rendering, panoramas, video
Visual editing and review	Adobe Photoshop CS5 / Premiere	Visual adjustment and editing of the video tour
Immersive tour	3D vista virtual tour	Integration of panoramas, hotspots, and multimedia content

Figure 12: Image of the head of the Collegiate Church.

[2] This algorithm makes scenes look more realistic, but it has the disadvantage of reducing FPS (frames per second) performance, affecting the fluidity of movement in the scene more than the image quality.

[3] PBR stands for “Physically Based Rendering” and is not just a texture, but a shading and rendering methodology based on the physical laws of light behaviour in the real world (Pietroni et al, 2021).

5. Results

5.1. Rendering

As mentioned above, the virtual restoration of this building has been characterised by the conservation of part of the construction elements in a state of consolidated ruin.

Although the building has been abandoned since the 18th century, its remains still show key features that help us understand its form. Both the base wall and the Gospel side retain the pilasters, their plinths, and capitals. The distance between these pilasters is also important, creating a plan view that clearly defines the church's structure into naves and bays. Likewise, the shape of the small columns forming the wall pilasters clearly defines the shape of the freestanding pilasters that divided the naves and were arranged where the cypress trees stand today.

The height of the naves is determined by the position of the pilaster capitals on the Gospel wall, complemented by information from the base wall of the church, which confirms the height of the side naves and describes the span the central nave once reached (Fig. 10).

As for the arches, their starts from the capitals show Gothic archivolts in continuation with the small columns of the pilasters, clearly indicating the ogival layout of the arches. Regarding the temple's roofing, it did not have vaults, as would have been usual in this type of church in the 14th century, but, according to surviving news, the entire space was covered by a large wooden collar-beam roof (Urrea Fernández, 2021: 18).

For the virtual restoration, a Mudejar coffered ceiling was arranged, distinguishing three distinct sections: the side naves were covered with rafters in the direction of the roof's greatest slope, a conventional and decisive solution. In the central nave, a larger and more complex coffered ceiling was arranged, composed of inclined rafters on the sides, with the central section resolved by horizontal beams, like the frame of a ship turned upside down. Due to the width of the central nave, this type of roof truss was braced with pairs of stays to prevent the walls from laterally collapsing under the horizontal forces they supported. Finally, there are the spaces of the collegiate church's transept. These pieces would have a hipped roof with ribs at the four corners, giving an appearance similar to an elongated octagon. However, the church's chancel, composed of two ultra-semicircular apses and one straight apse, was covered with barrel vaults and pointed barrel vaults, all in ashlar.

The other great enigma of the building, which the virtual restoration clarifies, is the representation of the chapter choir located in the central nave. This choir space was closed on three sides and opened onto the presbytery of the collegiate church. The dimensions of this space have been determined by combining a plan describing this space (Fig. 13a) with the dimensions of the stalls that have been preserved in various rooms of the current Valladolid Cathedral (Fig. 4).

The front was closed with a wooden grille. In this case, the grille of the choir of the collegiate church of San Bartolomé of Belmonte (Cuenca) was used as a reference. Due to the size of the choir space, the grille would be composed of two sections. The perimeter enclosures of this type of choir were resolved by a thick wall in which two side entrances to the central choir were located. Within the rear wall was the staircase leading to the upper level, which remained hidden, visible from the outside through an access door. This wall of the transept housed the altarpiece of Christ (Urrea Fernández, 2021: 17), Fig. 14.

This entire choir section was crowned with a C-shaped terrace, the perimeter of which was topped with a turned wooden railing. Two organs were placed on the side walls. Neither has survived, but there is evidence that the one on the Gospel side was similar to the organ in the Collegiate Church of Lerma (Burgos) and the one on the Epistle side is similar to that of Salamanca Cathedral. Therefore, they have been restituted to their original locations, giving the impression of the scale they must have had in comparison to the Collegiate Church (Fig. 13b).

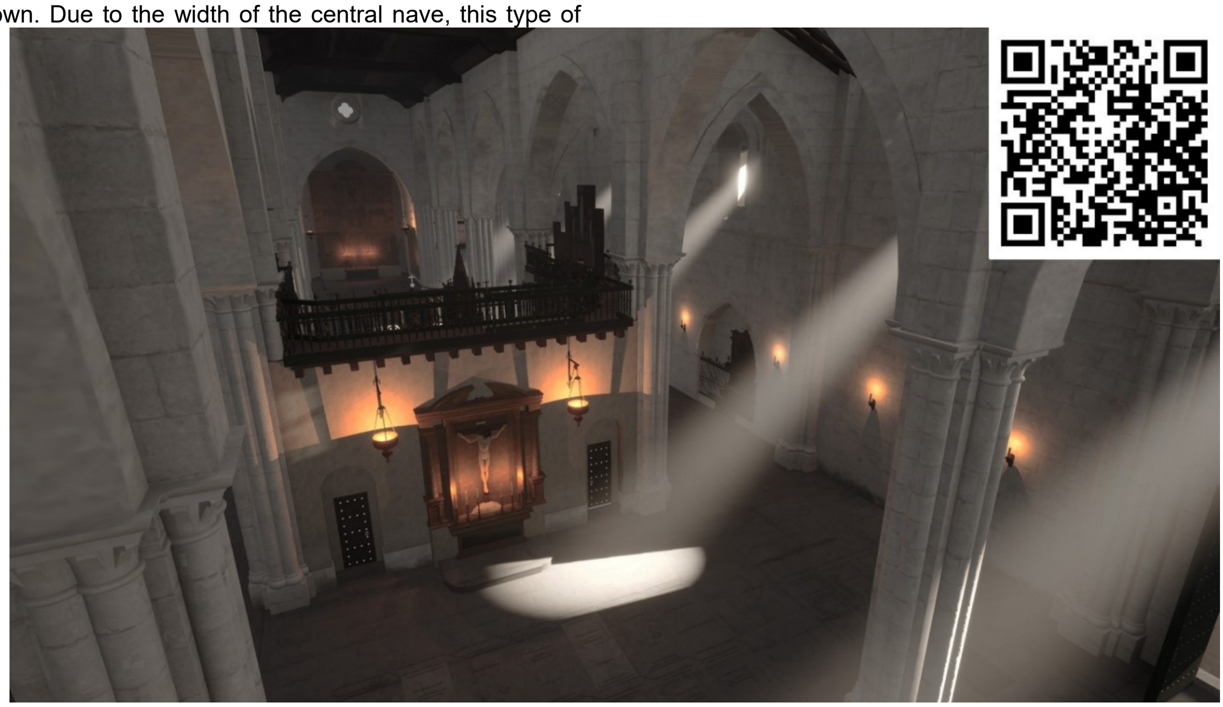


Figure 13: Render of the back of the choir and QR code to view the video render of the interior of the Collegiate Church.

5.2. Video rendering

Once the entire interior space was modelled and rendered, a video rendering was created to dynamically depict the Valladolid Collegiate Church[4].

Creating a video in a 3D environment in Twinmotion is based on the interpolation of camera movements along a path defined by keyframes. This process allows for the simulation of virtual walkthroughs or camera flights within the 3D model, facilitating a dynamic representation of the modelled architectural space.

To do this, a series of control points or keyframes is established that determines the camera's position and orientation at specific moments in time. Each of these keyframes contains information about spatial parameters (position, rotation, height, tilt) and, optionally, other attributes such as field of view or depth of field. Twinmotion uses linear or smooth interpolation algorithms to calculate transitions between these points, generating a continuous, fluid trajectory over time.

The Twinmotion camera system also allows for controlling the speed, acceleration, and overall duration of the clip, allowing the motion to be synchronised with other visual or audio elements. The result is an animated sequence that can be exported as a video in various formats and resolutions, ready for distribution in architectural visualisation, virtual museography, or design project presentations.

It seemed advisable to begin the visit from the exterior of the church, at the site once occupied by the Lion's Portico, entering through the transept, a somewhat unusual entrance for this type of church. Once inside, the tour of the collegiate church begins in the Epistle Nave and continues to the lower part of the church, where the central sacred way, the choir grille, and the side chapels are viewed. Once in the lower part of the church, the current state of the access arch from the cloister to what was once the Collegiate Church is shown, which remains in the same location, although blocked up. The tour continues through the retrochoir, the side entrance on the Gospel side, the side chapels, and, reaching the transept, shows the tomb of Count Ansúrez in its original location.

Moving through the side chapels of the presbytery, we can see the railings they once had, currently in the neighbouring Cathedral. In the centre, the altarpiece currently in the town of Amusquillo, and adorning its walls are placed the red velvet hangings embroidered with gold thread that now hang in the French castle of Chambord. The tour continues along the sacred way, comparing them with the current remains in what has come to be known as "the cypress garden". We move toward the choir, passing through its wooden railing and viewing the chairs and the central lectern with the hymn books. The video rendering concludes with a flight over the choir, which more clearly shows the two organs and the structure of the wooden roof, which had to be overlit to appreciate the patterns of the inlaid ceiling assembly.

5.3. Virtual tour

As part of the presentation of the results, it was deemed appropriate to develop an interactive virtual tour that would allow the observer to explore the collegiate church's interior independently and without restrictions. This aims to provide an immersive experience that allows for a detailed and in-depth appreciation of the architectural space, facilitating understanding of its structural and artistic elements from a unique perspective.

To structure this virtual experience, 16 vantage points were designed, distributed logically and coherently throughout the building's floor plan (Fig. 15). Each point was intended to offer optimal perspectives on the collegiate church's key architectural elements. Spherical cameras were installed, providing 360º panoramic images (Moreno Alcaide et al, 2024), allowing the observer a complete and detailed view of each space. The 360º renderings were generated using Twinmotion (Fig. 14).

Figure 14: 360º view of the interior of the chapter choir.

[4] The video can be viewed using the QR code in Fig. 14 or at https://youtu.be/8Ip-yPJoLR0

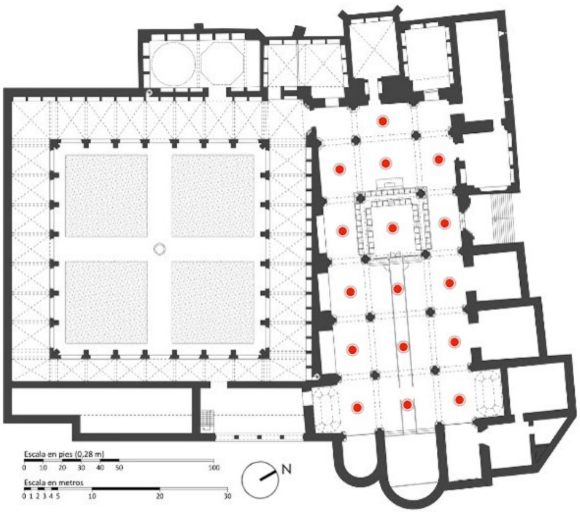


Figure 15: Map of the location of the different points of the virtual tour.

The process of creating a spherical panoramic visualisation in Twinmotion begins with the definition and positioning of the focal point, which will serve as the exact centre of the 360º projection. Upon selecting the panorama creation function, the software registers a spherical virtual camera object at the observer's current location. The precision of this camera's spatial location is paramount, as it determines the origin of all light rays and projection lines that construct the final image. It is important that the camera's altitude is accurately calibrated, typically adjusting to average human eye height to simulate a faithful and immersive viewing experience. Once the 3D position is defined, this spatial point is fixed as the geometric centre from which the rendering engine simulates the complete capture of the environment, encompassing the entire visual sphere, ensuring a coherent equirectangular map. The graphics engine processes this capture to produce a single two-dimensional image with a 2:1 aspect ratio.

For the integration and visualisation of the spherical images, the 3DVista Virtual Tour Pro software, specialised in the creation of interactive virtual tours, was used. This software allows links between the different spherical photographs to be generated through interactive points called "hotspots." These hotspots play a crucial role in navigation within the virtual tour, as they facilitate progress between different panoramas and allow the user to actively interact with the displayed content. In addition to facilitating the transitionbetween views, the hotspots can also integrate additional multimedia elements, such as explanatory texts, complementary images, informative videos, and narrative audios, which enrich the experience.

Implementing these interactive points not only improves navigation but also enhances the educational and cultural aspects of the visit. Users can customise their tour, stopping at specific points to obtain additional information, or explore visual and audio content related to the elements of the Collegiate Church that interest them most. This approach allows for more dynamic, participatory learning, tailored to the observer's needs and pace.

6. Discussion

The virtual reconstruction of the Santa María la Mayor Collegiate Church has not only enabled the visualisation of a vanished building but also the questioning, refining, and complementing of existing historiographical knowledge of its spatial, liturgical, and material configuration. In line with other recent studies on lost architecture (Llopis Verdú et al, 2024; Mizrahy Cuperschmid et al, 2024), this work demonstrates that virtualisation is not merely a graphic result, but an analytical process capable of generating new hypotheses and contrasting previous interpretations.

One of the most significant results is the confirmation of the church's monumentality, both in its plan and its height. Although the bibliography already noted the architectural relevance of the medieval collegiate church, the 3D modelling reveals an interior scale greater than previously intuited and difficult to appreciate from traditional documentation. This finding aligns with observations from similar research on vanished or transformed medieval cathedrals (Pàmies et al, 2023), where digital reconstruction has highlighted dimensions and spatial relationships previously underestimated.

Unexpectedly, the process revealed the decisive influence of lighting conditions on the spatial experience. Nearly all digital reconstructions analysed comparatively tend to privilege an illuminated scene to facilitate visual comprehension of the model. However, in this case, the historical simulation of light—limited and dependent on artificial sources—revealed a markedly dark interior atmosphere. This conclusion necessitates reconsidering the temple's original perception and its relationship to the liturgy, in line with recent studies on luminous atmospheres in medieval sacred environments.

Likewise, the reconstruction of the choir and its furniture provided relevant information on the organisation of the liturgical space and the use of visual and acoustic barriers. While certain elements coincided with those documented in coeval Castilian buildings, other aspects—such as the visual hierarchy between the choir, presbytery, and lateral accesses—differ slightly from usual typological patterns, raising new lines of research into local particularities in Valladolid's religious architecture. This partial divergence from reference examples, as in the collegiate church of Lerma (Burgos) or the cathedral of Salamanca, underscores the importance of approaching restitution processes from contextualised, rather than exclusively comparative, perspectives.

Finally, the implementation of real-time engines introduced a relevant experimental dimension, allowing for the evaluation of volumetric, luminous, and material hypotheses with an immediacy difficult to achieve using traditional representation methods (Rodrigues et al, 2014; Ferdani et al, 2020a). This capacity for iteration contributed to identifying inconsistencies and refining formal solutions, reinforcing the consideration of interactive visualisation as a scientific tool, beyond its communicative function.

Figure 16: Choral space image.

Collectively, the results obtained demonstrate that virtual reconstruction, when grounded in historiographical criteria and principles of methodological transparency, not only reproduces existing knowledge but also expands, corrects, or refines it. Furthermore, they open new opportunities for the study and dissemination of lost heritage, supporting the idea that virtual archaeology constitutes an essential resource for architectural research and the critical reconstruction of the built past (Guidi et al, 2011; Günay, 2022).

7. Conclusions

The development of this work demonstrates the potential of virtual restitutions when used as a research tool. The graphic method helps verify the feasibility of written testimonies and situates each piece (furniture or building) in the place it occupied centuries ago. Virtual restitutions have great potential in the architectural analysis of lost heritage, provided they are carried out with rigour and by an interdisciplinary team that combines their diverse approaches toward a common goal, creating informative content that does not preclude the scientific approach that this type of work necessarily entails.

Thanks to this virtual restitution, the spatial qualities of this church have been discernible. Its main characteristic is the Collegiate Church's large scale, both in its plan view and its correspondence with the church's great height (section). This interior spatiality was characterised by its other quality: the darkness of the Collegiate Church's interior. The lack of lighting was due to the fact that, as the central nave was no higher than the side naves, the lighting came from the narrow Gothic windows located on the access wall to the side chapels. In fact, in the images and videos resulting from this work, over-illumination was required to fully appreciate the various elements of the church's interior. Due to this lack of interior light, artificial lighting (candles and lamps) would be necessary, even during daytime rites.

The implementation of real-time graphics engines demonstrates that tools such as Unreal Engine and Twinmotion not only optimise workflow and processing times, but also enable an accurate, realistic, and scientifically valid spatial representation of lost architectural heritage.

The results presented in Section 4 confirm that the combination of historical documentation, 3D modelling, and immersive visualisation offers an effective way to reconstruct complex architectural hypotheses, facilitating both their academic validation and their dissemination through renders, video renderings, and interactive virtual tours.

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References

Aparicio Resco, P. (2021). Guía para la documentación de reconstrucciones virtuales de bienes patrimoniales. *Schema*, *2*, 129–146.

Bianconi, F., Filippucci, M., Cornacchini, F., Meschini, M., & Mommi, C. (2023). Cultural heritage and virtual reality: Application for visualization of historical 3Dreproduction. *International Archives of the Photogrammetry, Remote*

Sensing and Spatial Information Sciences, *XLVIII*(M-2–2023), 203–210. https://doi.org/10.5194/isprs-Archives-XLVIII-M-2-2023-203-2023

Borghini, S., & Carlani, R. (2011). Virtual rebuilding of ancient architecture as a researching and communication tool for Cultural Heritage: aesthetic research and source management. *Disegnarecon*, *4*(8), 71–79. https://doi.org/10.6092/issn.1828-5961/2571

Cáceres-Criado, I., Triviño-Tarradas, P., Valderrama-Zafra, J. M., & García-Molina, D. F. (2022). Digital preservation and virtual 3D reconstruction of “The Baker’s house” in the archaeological site of Torreparedones (Baena, Córdoba-Spain). *Digital Applications in Archaeology and Cultural Heritage, 24*. https://doi.org/10.1016/j.daach.2022.e00218

Demetrescu, E., d’Annibale, E., Ferdani, D., & Fanini, B. (2020). Digital replica of cultural landscapes: An experimental reality-based workflow to create realistic, interactive open world experiences. *Journal of Cultural Heritage*, *41*, 125–141, https://doi.org/10.1016/j.culher.2019.07.018

Di Mascio, D., Chiuini, M., Fillwalk, J., & Pauwels, P. (2016). 3D Digital Reconstructions of Lost Buildings. A first critical framing. In A. Herneoja, T. Österlund, & P. Markkanen (Eds.), *Proceedings of the ECAADE 2016: Complexity & Simplicity,* vol. 2, 511–522. Oulu, Finland: University of Oulu.

Ferdani, D., Fanini, B., Piccioli, M. C., Carboni, F., & Vigliarolo, P. (2020a). 3D reconstruction and validation of historical background for immersive VR applications and games: The case study of the Forum of Augustus in Rome. *Journal of Cultural Heritage*, *43*,129–143. https://doi.org/10.1016/j.culher.2019.12.004

Ferdani, D., Demetrescu, E., Cavalieri, M, Pace, G., & Lenzi, S. (2020b). 3D modelling and visualization in field archaeology. From survey to interpretation of the past using digital technologies. *GROMA: Documenting Archaeology*, *4*. https://doi.org/10.12977/groma26

Fernández Ruiz, J. A., & Gómez Robles, L. (2013). Lost Cities, Recovered Cities: Technology in the Service of the Past. *Virtual Archaeology Review*, *4(9)*, 48–57. https://doi.org/10.4995/var.2013.4247

Gimeno Sanz, C., Moral García, A., & Carazo Lefort, E. (2023). Cuatro trazados de la Catedral de Valladolid en un dibujo. La nueva copia del plano de Rivera Manescau. *EGA Revista de Expresión Gráfica Arquitectónica*, *48*, 156–167. https://doi.org/10.4995/ega.2023.19882

Guerrero Vega, J. M., Angulo Fornos, R., & Pinto Puerto, F. (2023). Interpretation of the Remains of the Church of the Monastery of San Jerónimo De Buenavista (Seville) Based on a Multifocal Approach and the Creation of a Digital Model. *SCIRES-IT, 13*(2), 43–60. https://doi.org/10.2423/I22394303V13N2P43

Günay, S. (2022). Virtual reality for lost architectural heritage visualization utilizing limited data. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVI-2/W1-2022, 253–257. https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-253-2022

Guidi, G., & Russo, M. (2011). Diachronic 3D reconstruction for lost cultural heritage. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XXXVIII-5(W16), 371–376. https://doi.org/10.5194/isprsarchives-XXXVIII-5-W16-371-2011

Llopis Verdú, J., Gutiérrez-Pérez, N., & Cabodevilla-Artieda, I. (2024). Virtual reconstruction of the disappeared Valencia Oil Market (Spain). *Virtual Archaeology Review*, *15*(31), 86–103. https://doi.org/10.4995/var.2024.21148

López Bragado, D., Alonso Rodríguez, M., & Lafuente Sánchez, V. (2021). Restitución virtual de la capilla del desaparecido convento de Santa Marina de Zamora. *DisegnareCon*, *14*(27), 701–714. https://doi.org/10.20365/disegnarecon.27.2021.7

Mizrahy Cuperschmid, A. R., Prado Costa, A., Neves, I., Raffaelli Fonseca, F., & Mizrahy Cuperschmid, E. (2024). Virtual Reconstruction of the Deconstructed Heritage: The Former Building of the Belo Horizonte School of Medicine. *Journal on Computing and Cultural Heritage*, *17*(2), 21. https://doi.org/10.1145/3639931

Moreno Alcaide, M., Román Punzón, J. M., & Valdivia García, M. (2024). Application of digital technologies for virtual reconstruction of the Roman Villa of Salar (Granada, Spain): an example of archaeological heritage transfer. *Virtual Archaeology Review*, *16*(32), 130–143. https://doi.org/10.4995/var.2024.22364

Ortega Vidal, J., Martínez Díaz, A., & Muñoz de Pablo, M. J. (2011). El dibujo y las vidas de los edificios. *EGA Revista de Expresión Gráfica Arquitectónica*, *18*, 50–63. https://doi.org/10.4995/ega.2011.1335

Pàmies, C., Sánchez, A., & Navarro, I. (2023). Virtual reconstruction of decontextualized heritage the case of the Cathedral of Girona. *DisegnareCon*, *16*(30), DW.1–DW.14. https://doi.org/10.20365/disegnarecon.30.2023.8

Pietroni, E., & Ferdani, D. (2021). Virtual Restoration and Virtual Reconstruction in Cultural Heritage: Terminology, Methodologies, Visual Representation Techniques and Cognitive Models. *Information*, *12*(4), 167. https://doi.org/10.3390/info12040167

Remondino, F., & Campana, S. (2014). 3D surveying and modeling in archaeology and cultural heritage. Theory and best practices. *British Archaeological Reports*, Int. Ser. 2598, Oxford.

Rodrigues, N., Magalhães, L., Moura, J., & Chalmers, A. (2014). Reconstruction and generation of virtual heritage sites. *Digital Applications in Archaeology and Cultural Heritage*, *1*(3–4), 92–102. https://doi.org/10.1016/j.daach.2014.06.003

Rua, H., & Alvito, P. (2011). Living the past: 3D models, virtual reality and game engines as tools for supporting archaeology and the reconstruction of cultural heritage – the case-study of the Roman villa of Casal de Freiria. *Journal of Archaeological Science, 38*(12), 3296–3308. https://doi.org/10.1016/j.jas.2011.07.015

Soto-Martín, O., Fuentes-Porto, A., & Jorge, M.-G. (2020). A Digital Reconstruction of a Historical Building and Virtual Reintegration of Mural Paintings to Create an Interactive and Immersive Experience in Virtual Reality. *Applied Sciences*, *10*(2), 597. https://doi.org/10.3390/app10020597

Urrea Fernández, J. (2021). *La Catedral de Valladolid. Su historia y Patrimonio*. Valladolid: Ayuntamiento de Valladolid.

Valle Abad, P., Fernández Fernández, A., & Rodríguez Nóvoa, A. A. (2022). Lost archaeological heritage: virtual reconstruction of the medieval castle of San Salvador de Todea. *Virtual Archaeology Review*, *13*(26), 22–44. https://doi.org/10.4995/var.2022.16178

Viscogliosi, A., Borghini, S., & Carlani, R. (2006). L'uso delle ricostruzioni tridimensionali nella storia dell'architettura: immaginare la Domus Aurea. In Haselberger, J. & Humprey, D. (Eds.) *Imaging Ancient Rome. Documentation-Visualization- Imagination*, 207–219, Portsmouth, Rhode Island.