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Virtual reconstruction of a disappeared monastery of Santa Maria de la Murta

The representation of disappearing architectures is an important task for the recognition of our history. This article describes the process of digital reconstruction of the monastery of Santa María de la Murta, in Alzira, from the data obtained in the initial archaeological campaigns to the work of documentary research, graphic surveying and analysis of architectural remains. From this information, a video tour of the interior of the Church is produced, merging real images with the virtual reconstruction carried out.
The monastery is currently in a state of precariousness in which only a few walls of the church, the tower Las Palomas and the starts of what were the walls of the cloister, exhumed in the first archaeological campaigns remain. The monastery is catalogued with a high level of architectural protection within the section of fortified religious monuments, being considered one of the founding monasteries of the Order of Saint Jerome (the Hieronymites).
Thanks to the constructive hypothesis embodied in the 3D model, progress has been made in the knowledge of the monastery, using the virtual model as a tool of interpretation, simulation and scientific dissemination. The recovery, although only virtual, restores some of the loss, and has allowed to re-enjoy the spatial, visual and acoustic sensations that could occur in the missing buildings reinforcing both the interest for the good and the affective bond of the population linked to it.

Keywords:
Architectural heritage; cultural heritage; virtual reconstruction

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OBJECTIVE AND INTRODUCTION

Much of our built heritage has fully or partially disappeared over time. In such cases, the one of the best tools we can use to further our knowledge is virtual reconstruction. The process consists of using digital procedures to show how heritage sites would have looked in the past by interpreting their vestiges and examining any relevant historical documents that have survived to the present day.
Nowadays nobody would consider undertaking a heritage intervention project without applying these advanced documentation, representation and visualisation techniques, such as generating 3D models, restoration and recreation (Esclapés et al., 2013). The reliability of a reconstruction proposal depends to a great extent on the information that can be obtained from both documentary sources and archaeological excavations of whatever remains may be left of the building.
This paper posits a hypothesis for restoring the Monastery of Santa Maria de la Murta in Alzira. Subjected to exclaustration in the 19th century, the abandonment the monastery suffered following its confiscation led to its ruination and almost complete disappearance (Fig. 1). Based on a multidisciplinary intervention, with preliminary documentary and archaeological studies, a meticulous measured survey of the remains and a historical and typological study, it was possible to generate a virtual reconstruction of the complex. The formulation of a geometric hypothesis for its reconstruction was the basic instrument used to expand the study to various other areas, such as its construction and structure, as well as the acoustic behaviour of the church.
As a fundamental element of cultural heritage, the study of architecture in ruins or in the process of disappearing is a field open to the development of research conducted with virtual reality, digital models and architectural graphic expression. The generation of a digital model of a disappeared building makes it possible to carry out more detailed studies of its formal and construction characteristics, upon which virtual tours can be produced to recreate the sensorial experiences that could have been transmitted by the original spaces, forming an emotional connection with the viewer.


Fig. 1 - Aerial image of the current state of the remains of the monastery.

In the case of a disappeared building, the construction of a virtual model, provided that it is done with scientific rigour and based on precise studies of the object to be represented, advances our knowledge of the monument and therefore contributes to its historical recovery and appreciation as cultural heritage. Any pre-existing architectural elements still standing are fundamental to strengthening the reconstruction hypothesis. This is the case of the Monastery of Santa Maria de la Murta, given that the final model is based on studying the built remains of the monastery, consulting documentary sources and analysing other similar buildings.
It is also important to apply scientific methodology when representing heritage with computer technology from the graphic perspective. The virtual model has served as the foundation for a formal study, considering the architectural complex in its entirety within the surrounding area and contemplating solutions for the built components that define it. The production of the virtual model made it possible to spatially consider the proposed working hypotheses, in such a way that the model was updated upon their verification within an iterative process of successive adjustments.

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BACKGROUND. THE MONASTERY OF SANTA MARIA DE LA MURTA

The Monastery of Santa Maria de la Murta belonged to the Order of Saint Jerome (the Hieronymites). This order came into being in the late 14th century, at a time when a large number of orders (both observant and mendicant) had been fully developed, defining their way of life in accordance with monastic rules and creating buildings according to their needs. The Order of Saint Jerome was established to include within the Church various groups of hermits that had formed in remote locations in the Crowns of both Castile and Aragon. In 1373, Pope Gregory XI issued a papal bull recognising the order, whose operation was established under the Rule of Saint Augustine.

The Order of Saint Jerome (*Ordo Sancti Hieronymi*, abbreviated O.S.H.) was one of the most predominant in the Iberian Peninsula. Its special, mutually influential relationship with the Spanish monarchy favoured the exponential growth of the O.S.H. With respect to its architecture, this meant a sharp increase in the number of houses and monasteries, several of which were under the direct protection of the monarchs.

The O.S.H., supported by the monarchy and the aristocracy, came to possess significant built heritage in the Iberian Peninsula, which then became the property of the state or was held by private hands as a consequence of the confiscations that took place in the 19th century. The conservation of this architectural heritage was unequal. Some of the monasteries are still in good condition today (those of Sant Jeroni de Cotalba, Guadalupe, and Yuste, among others), while many other were subject to abandonment and ruination that led to their almost complete disappearance, as is the case of the Monastery of Santa Maria de la Murta.

With the aim of replicating Saint Jerome's ascetic withdrawal from the world, the order's first monasteries were located in areas far away from settlements. These monasteries did not conform to a common style, although the subsequent rapid evolution of the O.S.H. brought with it a uniform model similar to that of other orders, but with its own idiosyncrasies in reflection of the discipline imposed by its rules. These conditioning factors were soon increased through the order's association with the reigning monarchs, for whom they often served as temporary accommodation during their travels and hunting trips, which also led them to become the location chosen for their retirements and final days, as was the case of Charles V, Holy Roman Emperor and King of Spain, at the Monastery of Yuste, and later also of his son Philip II in the construction of the monastery of El Escorial (Fig. 2).

Fig. 2 - Image The Hieronymite Monastery of El Escorial.

Santa Maria de la Murta was one of the first Hieronymite monasteries in the Crown of Aragon. Erected on the site of a previous eremitic settlement, it was founded as a monastery when the hermits that occupied the valley decided to join the order. It is typologically related to the Monastery of Sant Jeroni de Cotalba, from which the O.S.H. expanded throughout the Crown of Aragon. Construction started in 1403 on the site of a pre-existing hermitage in an environment of a great natural value and beauty, and following successive extensions it reached the peak of its splendour in the mid-17th century under the patronage of the Vich family.

Despite being one of the smallest in terms of ground plan, the monastery included all the elements corresponding to a religious building of its type. The access space was configured as a semi-urban square, differentiating the entrances to the church and the enclosed monastery. The doors, located at the two ends of the square, were highlighted with architectural elements in the form of towers. Inside the monastery the rooms were organised around a two-storey cloister, with

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the refectory in the west wing and the church in the east wing. The monastery was closed off to the north with the kitchen area and the hospital for the poor. The tower of Las Palomas, built as a defensive measure to ward off possible attacks from Barbary pirates, stood at the farthest point from the entrance and was an iconic element of great visual power.
Within the confiscation process, the monastery was seized from the Church and passed into private hands. Building elements such as its wood and roof tiles were removed and sold, causing the building to quickly fall into ruin. Today all that remains standing is a few walls of the church, the tower of Las Palomas and the bases of the cloister walls, which were unearthed in the first archaeological digs. In the late 20th century, Alzira City Council purchased the property and started to excavate, study and conserve the remains, which enjoy a high level of architectural protection as a fortified religious monument.

WORK PROCESS

To imbue the virtual reconstruction of the monastery with the necessary scientific rigour, it was necessary to conduct a historical, archaeological and typological study to determine both the geometry of the building and its functional and construction characteristics. The shortage of physical and documentary information and data on the building made it necessary to study it from multiple disciplines.
Creating a virtual model means digitally constructing its architecture, which is governed by the same factors that determine its actual architecture, complying with structural stability, functionality and material suitability criteria. The data from archaeological excavations and surveys, documentary sources and hypotheses (technical and typological considerations, studies of measured and compositional proportions, etc.) guided the reconstruction choices upon which the virtual model is based.
The study started with an analysis of the dimensions and construction of the physical remains

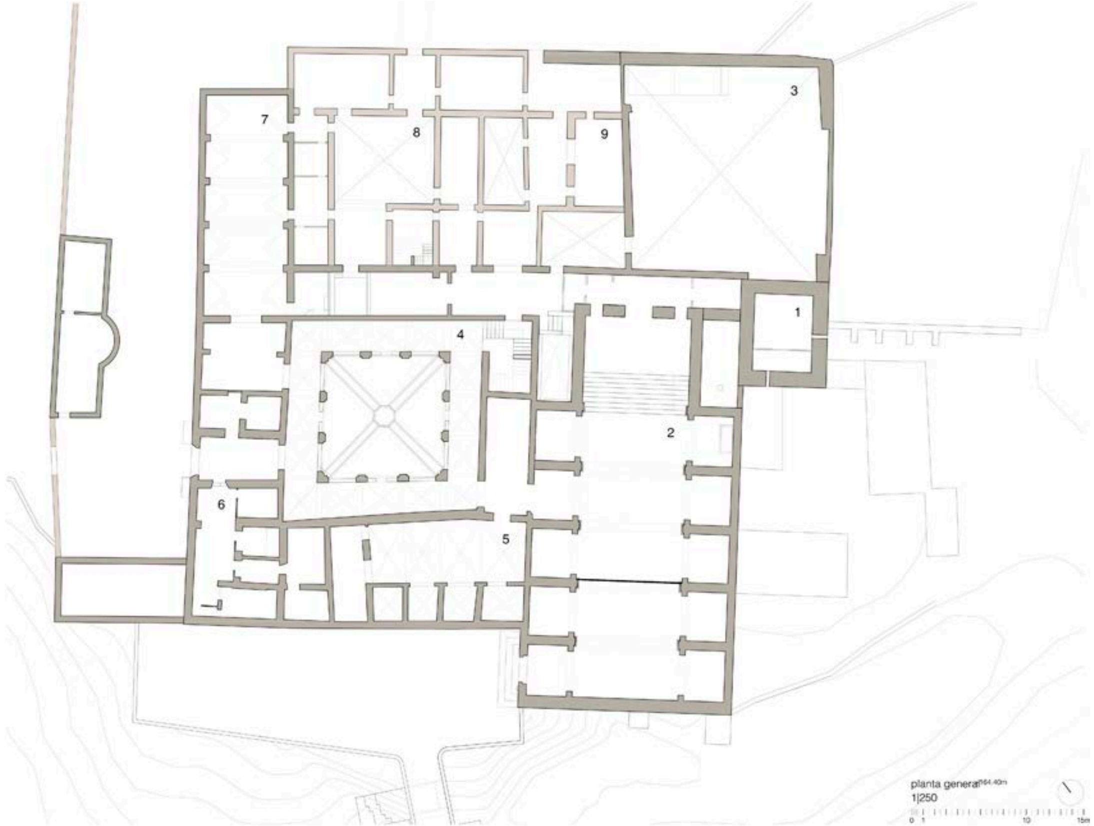

Fig. 3 - Ground plan distribution of the Monastery in 17th century. 1- Tower; 2-Church; 3- Courtyard; 4- Cloister; 5- Sacristy; 6- Porteria; 7-Refectory; 8- Kitchen courtyard; 9- Hospital

(walls, renderings, building systems, etc.) followed by a study of the historical documentation and comparisons with similar models still standing today.
The first task in the reconstruction process was to obtain a two-dimensional planimetric image to define the hypothetical morphology of the monastery complex, based on the survey, the historical data and the functional and typological analysis (Fig. 3).
The data gathering process started with traditional architectural survey methods, carrying out sketches of the architectural remains still standing and adding the data from the archaeological excavations. Historical research based on these data was then conducted, consulting documents, analysing the types of the various Hieronymite monasteries and studying the building characteristics of the period in which the Monastery of Santa Maria de la Murta was built.
Measuring the building or what is left of it is an essential part of developing the restitutive hypothesis. Given the difficult lie of the object of study (on a

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slope and in an area that is difficult to access and in which the architecture and topography may easily be confused), the planimetric survey was conducted using both manual and photogrammetric techniques. While the latter guarantee the precision of the data and the correct relationship between the built parts, manual techniques make it possible to focus on elements important to the survey.
New sketches were then done as a means of verification with the aid of new data gathered by laser scanning (Fig. 4), producing the two-dimensional planimetric drawing of the current state of the monastery. This drawing was undertaken from a methodological, scientific approach, supported by the analysis of documentary sources (graphic and written) and iterative verification over the existing architectural remains (Fig. 5).
Having completed the research process and produced the planimetric survey of the complex's current state, it was then possible to posit the hypothetical reconstruction of the complex at the height of the monastery's splendour. The construction of the model reflects all the sources that contributed to the chosen reconstruction: the data from the archaeological digs, the data gathered from the ruins, the data deduced from studying documents, and the hypothetical elements (technical and typological considerations, the study of proportions and measurements, and elements based on compositional considerations) (Fig. 6).

RECONSTRUCTIVE HYPOTHESIS
TYPOLOGICAL STUDY AND COMPARISON OF MODELS

The architecture of the Order of Saint Jerome, in contrast to that of other religious orders, such as the Carthusians and the Cistercians, does not present a specific typological layout

Fig. 4 - Image of the point clouds obtained by laser scanning the remains of the monastery.

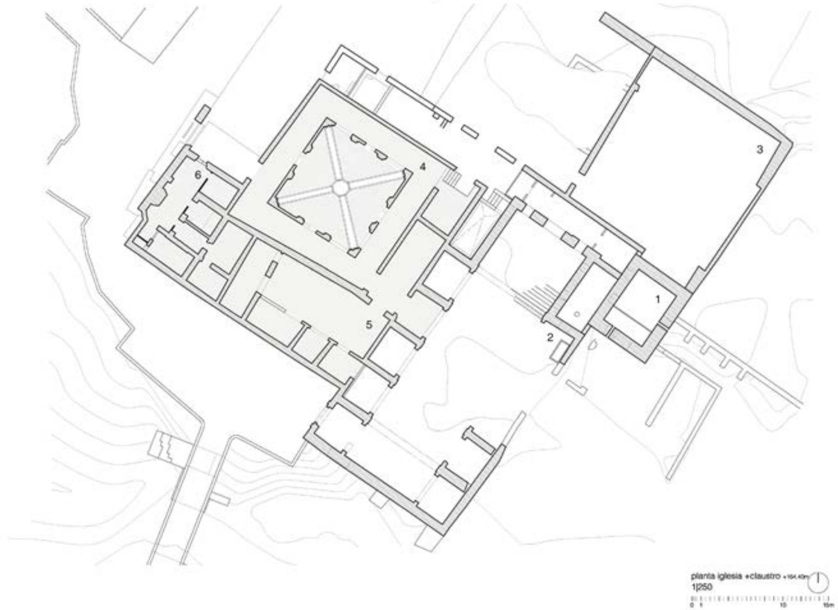

Fig. 5 - Survey of the current state of the monastery. 1- Tower; 2-Church; 3- Courtyard; 4- Cloister; 5- Sacristy; 6- Porteria.

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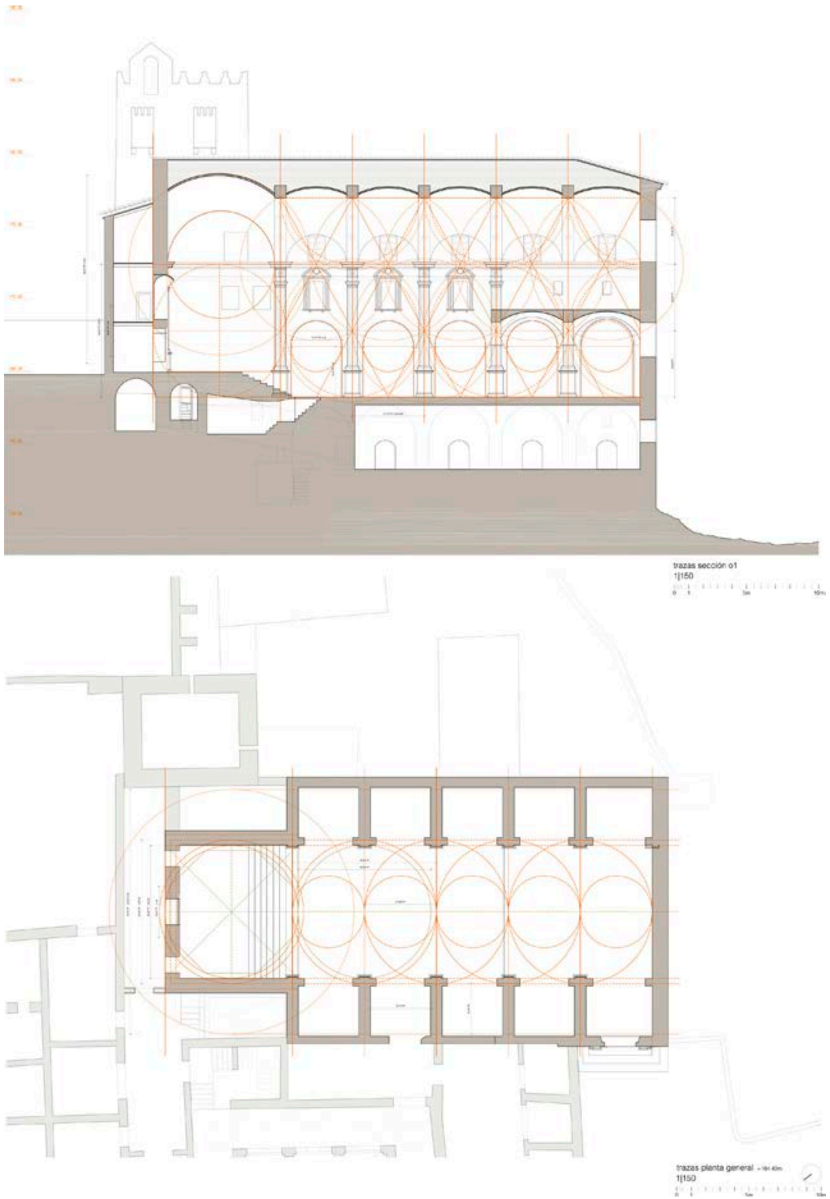

for its monasteries. The fundamental parts of all monastic architecture (church, refectory, cloister, etc.) appear, but with their own distinctive features, reflecting the way of life of the monks of the O.S.H. However, the relationship between the parts, their location within the setting and the general geometry of the building vary with each individual monastery (Arciniega García, 2001, pg 7-8, TII).
Ruiz (1997) and López-Yarto et al (1995) describe the common characteristics of the buildings of the order, and Sender (2014) describes the specificity of the monasteries of the Crown of Aragon, based on their common association with the house of Cotalba (Fig. 7). There are specific characteristics in the buildings that are repeated in the monasteries of the O.S.H., especially in the configuration of the church (Sender Contell, 2014), such as:

- The isolation and solitude of their houses.
- A church with a single nave with a large, high choir at the back.
- In the church, an elevated main chapel over steps with room for a crypt underneath them for burials.
- One or more cloisters.
- The importance of accommodation for lay brothers.
- An apothecary.

In conclusion, up until 1415 Hieronymite monasteries were made up of an area enclosed by a wall, within which was the church and a cloister. The church had a single nave with a high choir at the back and a raised chancel over steps. Outside there was a bell tower in an indeterminate location. In the cloister, which had two storeys (except in the case of Lupiana), were the common rooms and the cells. The former, consisting of the chapter house, refectory and linen room, were on the lower level, while the cells and common dormitories were on the upper level (Ruiz Hernando, 1997, p. 59).
The morphological hypothesis was established based on the basic plan of the building determined by the excavations and sketches and on comparisons with coetaneous monasteries.

Fig. 6 - New church reconstruction hypothesis.

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1.

2.

These studies made it possible to determine the approximate dimensions of partially excavated rooms, such as the refectory, the chapter house and the sacristy, and thereby to ratify the existence of elements that, although now defunct, could be deduced from the remains.
Once the hypothesis had been posited with two-dimensional planimetry (using Autodesk AutoCad software), it was possible to establish the sections that define the monastery complex. All the information that had been collected was transferred to a three-dimensional model (a virtual model created with Autodesk 3ds MAX software), structuring the data obtained from the hand-drawn sketches, the topographical survey and the laser scan in order to create a virtual model of what the monastery was like in the 17th century (Fig. 8) (Fig. 9).

THE VIRTUAL MODEL - CONFIRMATION OF THE HYPOTHESIS WITH STRUCTURAL ANALYSIS

Like many historical edifices, this building is the result of a complex evolution over a long period of time, in which new elements were added and others were replaced. The virtual model represents what the monastery would have been like in the 17th century, which is when the morphology of the building reached the height of its development.
The virtual model depicts in the greatest detail the new church, which is the part of the building conserving the most complete remains (part of the structural wall and the interior arches) and the part with the most reliable graphic and written documents. This church started to be built in 1516 and construction was subsequently halted for a period before being restarted in 1609 and then finally consecrated in 1623.
The graphic documentation and the vestiges remaining on the walls made it possible to propose at least two restitutive hypotheses for the roofing system of the main nave: a succession of ribbed sail vaults and a barrel vault with lunettes. The traces that remain on the walls allow for either

Fig. 7 - Comparative diagrams of the plans of the Monastery of Sant Jeroni de Cotalba and the Monastery of Santa Maria de la Murta.

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solution and the image that has come down to us is not determinant and there are discrepancies in the descriptions made by contemporary authors who wrote about it (López-Yarto Elizalde et al., 1995) (Arciniega García, 1999).
The periods of the two geometries overlap at the time of the church's construction. The first option, although clearly associated with classical styles, was inherited from the late Gothic tradition of rib vaults with a spherical envelope. The barrel vault with lunettes was the predominant type following the Counter-Reformation. Accordingly, if the constructive and stylistic transition from the Gothic to the Baroque is understood to be a continuum, sail vaults like the ones in the church of La Murta would lie at its centre. Both the architectural quality and spatiality and the structural behaviour would be very different in each of the possible geometries and they define the final result of the hypothesis for the construction of the model.
In the case of the church of La Murta, based on the reconstructive hypothesis, a comparative study was conducted on the structural behaviour of the possible geometric solutions of the vaults that could have been used in the church (spherical geometry sail vaults with or without ribs, barrel vault, and barrel vault with lunettes), including their rigidisation systems (cohesive filling and transverse walls supporting the roof board).
With respect to the building system used, the roof was built, in all likelihood, with tiled vaults, which had been adopted throughout the Crown of Aragon since the early 15th century as a load-bearing element. The remains of the spandrels of the vault of the high choir and the traces of the walls confirm this hypothesis.
The main characteristics of these vaults from the building perspective are their simple construction and their flexibility in terms of formal definition. The first leaf, which defined the geometry of the

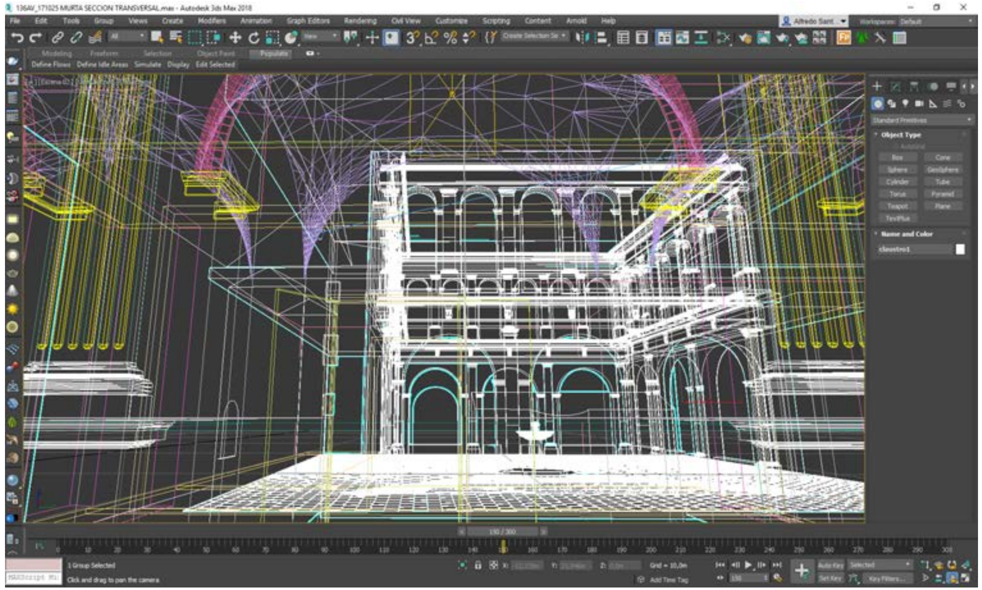

Fig. 8 - Wireframe of the interior of the church.

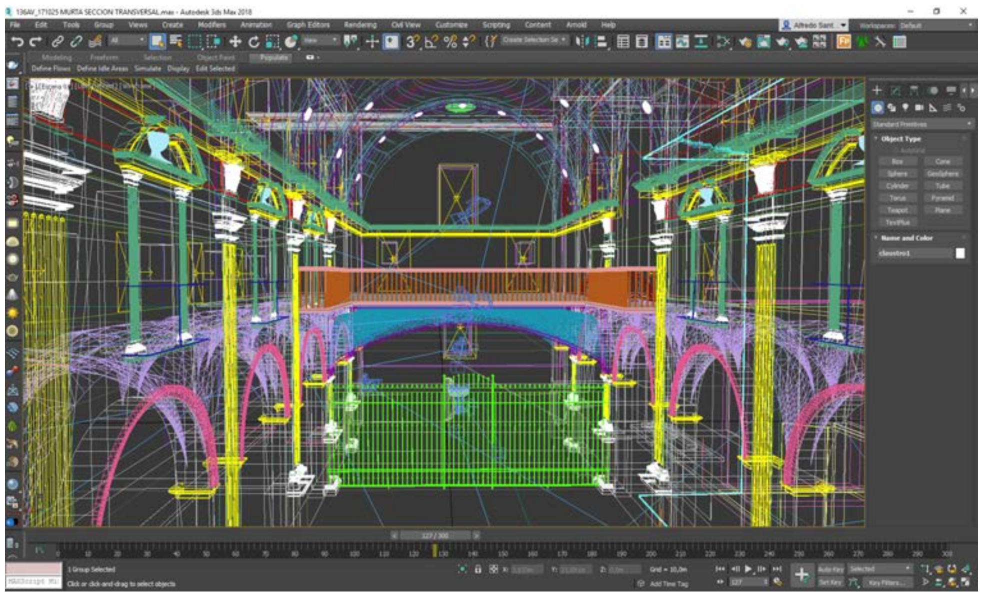

Fig. 9 - Wireframe of the interior of the church..

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intrados, was built without the need for centring. It was only necessary to have a guide to indicate the position of the bricks to be used for its construction. The pieces were attached with very quick-setting gypsum, which meant they could support their own weight almost immediately. Over this first leaf, which acted as support for the following leaves, the others were successively added in an interlocking manner. The economy of both resources and materials is undeniable. Using exclusively bricks with lime and gypsum mortars and with only very rudimentary auxiliary scaffolding and elevation elements it was possible to build a structure with significant spans capable of withstanding medium loads.

As they were composed of small pieces, their geometric layout was very free and enabled great flexibility without the need for the complicated cuts and complex volumes required with ashlars. This allowed for a lack of rigour in form when building them, making their virtual reconstruction more difficult to achieve. The system made it possible to "deceive" or "lie" in the geometry with great ease in order to adapt to the irregularities of the actual work [1]. Accordingly, their final form depended, to a great extent, on the skill of the craftsman.

In our case, given the impossibility of obtaining the exact geometry, for both the structural study and the virtual reconstruction we used perfect ideal geometries: spheres and cylinders with a circular directrix.

The structural study (Perelló Roso, 2015) was tackled with two parallel processes. First, a classical analysis of equilibrium approach was conducted with a graphic statics' method (Fig.10) (Fig. 11), which made it possible to intuitively approach the behaviour of the structure and validate the hypotheses in relation to vertical loads.

Second, a structural study was carried out on the various models using the finite element method by ANGLE software (Alonso Durá, 2014). The geometry defined in the virtual reconstruction was used to generate a 3D model, in which the walls and buttresses are represented by 3D volumetric elements, which simulate the actual geometry and dimensions, and the vaults and strengthen-

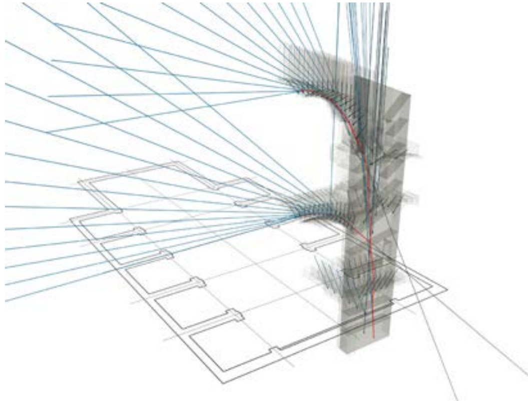

Fig. 10 - Resultant of loads on the abutment supporting the arch of the choir (3D).

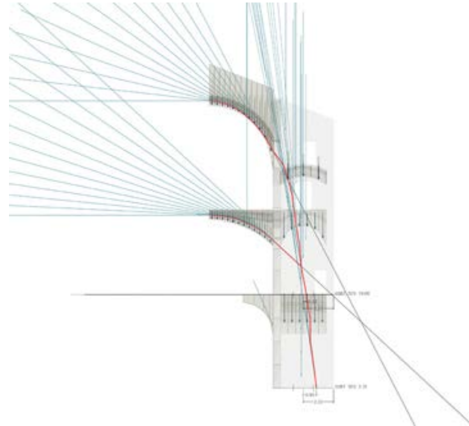

Fig. 11 - Resultant of loads on the abutment supporting the arch of the choir (2D).

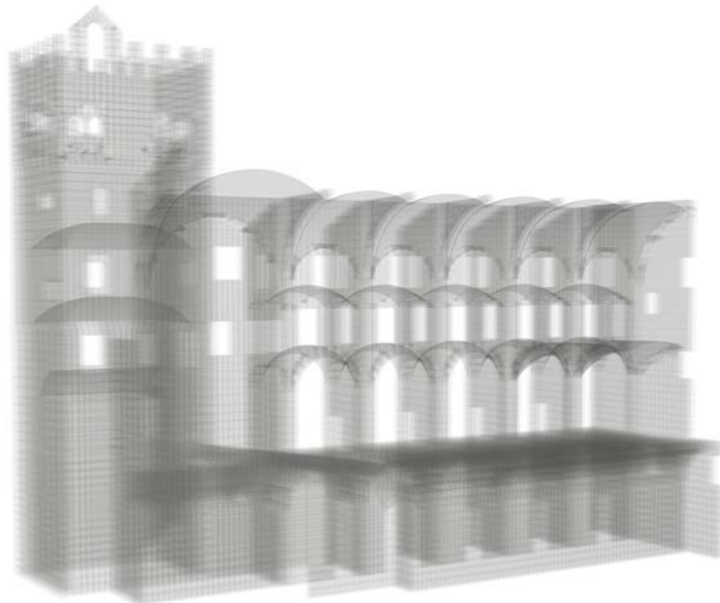

Fig. 12 - Mesh for the FEM calculation.

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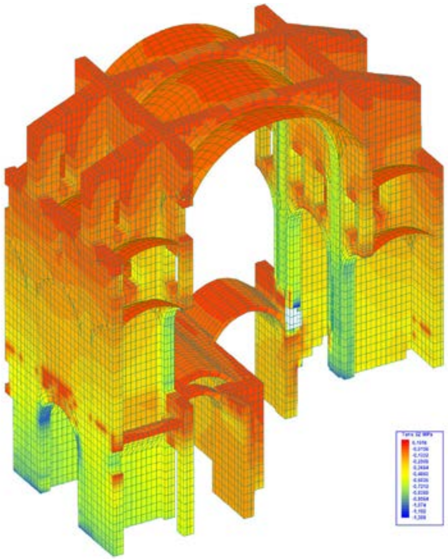

Fig. 13 - MEF calculation results

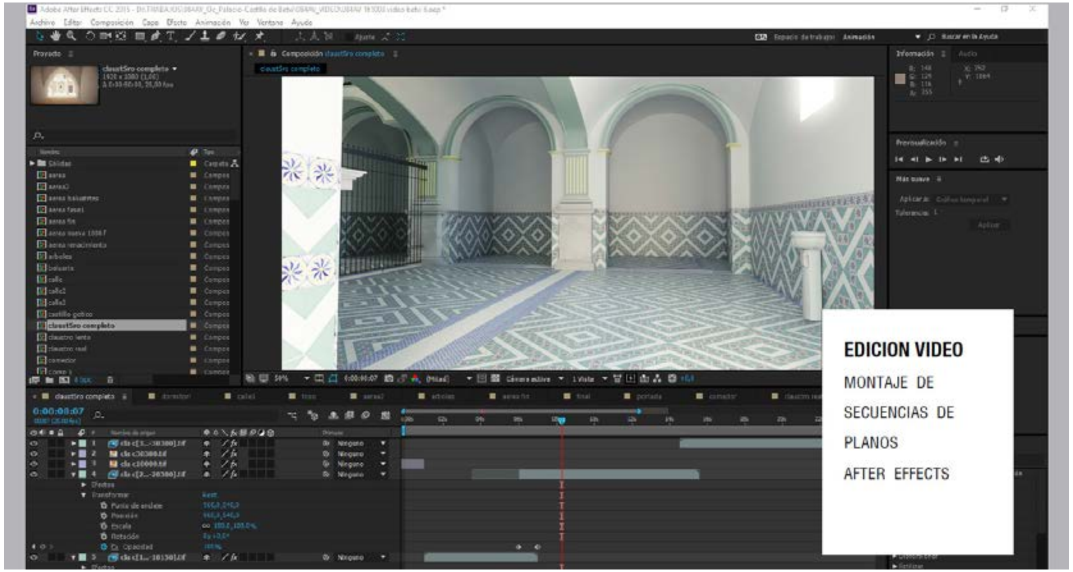

Fig. 14 - Image of the video editing process.

ing supporting walls are represented by surface finite elements.
The model generated for the analysis of mechanical behaviour (Fig. 12) was based on that used for the architectural reconstruction but adapted to the needs of the structural calculation process. The distribution of the finite elements needs to be homogenous and stick within a given range of dimensions to ensure that the calculation truly reflects said behaviour. Similarly, the nodes defining the finite elements need to be connected to each other in order to reflect the continuity of the masonry. These mesh characteristics, which are not at all important in the architectural reconstruction, are essential in the structural calculation model.
The behaviour of the masonry made it necessary to apply non-linear analysis in both the geometry and the mechanical response of the material. The models have been studied in an incremental-iterative nonlinear static analysis, in which the structure is subjected to vertical actions step-by-step until its peak-load and beyond that into the post- peak regime. In that case, the simulation has been done in event-by event damage control, assuming mechanical non-linearity for the material, and the very different tensile and compressive strengths of the masonry. The material has been modelled as a continuum deformable body with distinction between bricks and stone elements [2] (Fig. 13). This process obtained the actual collapse load value of the structure, making it possible to compare the various vaulting solutions that were studied.
The ribbed sail vault with spherical directrix was the solution with the best structural behaviour of those studied, obtaining collapse load values much higher than those estimated for the actual structure.
Accordingly, the structural analysis validated the geometric and building model of the reconstruction hypothesis and could be used to support the study of the acoustic performance of the church and produce an immersive virtual tour capable of transmitting spatial sensations.

- ACOUSTIC STUDIES - THE AURAL REPRODUCTION OF THE SPACE OF THE CHURCH

Hieronymite monks were known for the grandeur of their liturgical celebration, in which music—both choral and accompanied with the organ and other instruments—played an important part.
In Sender et al (2017) the behaviour of the temple was analysed in terms of the spoken word and music. The text used for the spoken analysis was a reading of psalm 29, from which an inscription appears on the facade of the church. For the study corresponding to music, *Pange Lingua*, an organ piece composed by friar José Pereandreu, the master of the monastery's chapel choir in the mid-17th century, was played.

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The auralisations were carried out taking into account the sound emission positions (officiant, organ music and singing of the monks) and the possible locations of the listener in the church during the liturgy. This applied the functional zoning description of a prototypical Hieronymite church provided by Ruiz (1997), which clearly established the positions of officiant, monks, illustrious visitors and lay brothers during services. The study gathers objective data on the acoustic performance of the hall and, by means of the generated audios, the immersive experience of the spectator in the various locations within the church.

- FINAL PHASE OF THE PROCESS: VIRTUAL TOUR VIDEO

In the final phase of the process, taking as the base the digital model of the reconstruction hypothesis of the monastery, work was done to prepare an interior tour video in order to better reach the viewer, through the physical sensation of immersion in the spaces. The video editing was carried out with the programs Adobe Premier and Adobe After Effects (Fig.14).
As with the virtual reconstruction, a large team of researchers and specialists in the field of architectural heritage participated in the preparation of the video. After carrying out the modelling, texturing and rendering processes, the Universitat Politècnica de València's drone was used to obtain the final images of the monastery's environment. The images of the valley surrounding the monastery and those taken by the drone as it flew over the ruins were used to merge the virtual model with the current state of the complex, carrying out transitions between them to help the spectator participate in the immersive experience.
The development of the video required intensive editing work to assemble the shot sequences and to adjust the images, colours, exposure, effects and transitions between the reality of the valley and the virtual model. The video simulates the route from the exterior of the monastery, on the other side of the access bridge, through the facade of the church to the interior of the nave and finally passing through to the cloister, blending images of the virtual model with images of the actual situation to ensure that the location of the pieces over the remains is easy to recognise (Fig. 15).
The work process consisted firstly of using the three-dimensional model prepared in 3ds to generate the rendering of the model, applying textures and materials based on building elements recovered in the archaeological digs (ceramic renderings, ashlars and quarry stones, remains of stucco on vertical faces...) (Fig. 16) (Fig. 17).
Finally, to complete the video, special care was taken when selecting the soundtrack accompanying the images. The Alzira composer Javier Quilis generously facilitated the use of his composition El Monasterio de la Murta, which was inspired by the ruins of the monastery. Music and images complement each other to highlight the sensations transmitted on the tour, creating an immersive and spiritual experience for the viewer (Fig. 18).
The town of Alzira has a powerful emotional link with the ruins of the monastery. This work makes it possible to see what the building was like, making its idealised image—unknown for much of the population, and to some extent mythologised—tangible. Its comparison with the ruins increases the value of the heritage asset, fosters ties to it and highlights the need to protect, conserve and improve the remains.

CONCLUSIONS AND RESULTS

The ideal reconstruction of disappeared architecture through virtual reality is a powerful tool. Digital models have proven to be a highly effective means of studying the behaviour of a building in relation to a number of different aspects (constructive, structural, thermal, acoustic, etc.) and

Fig. 15 - Image of the immersive virtual model in the real image of the valley.

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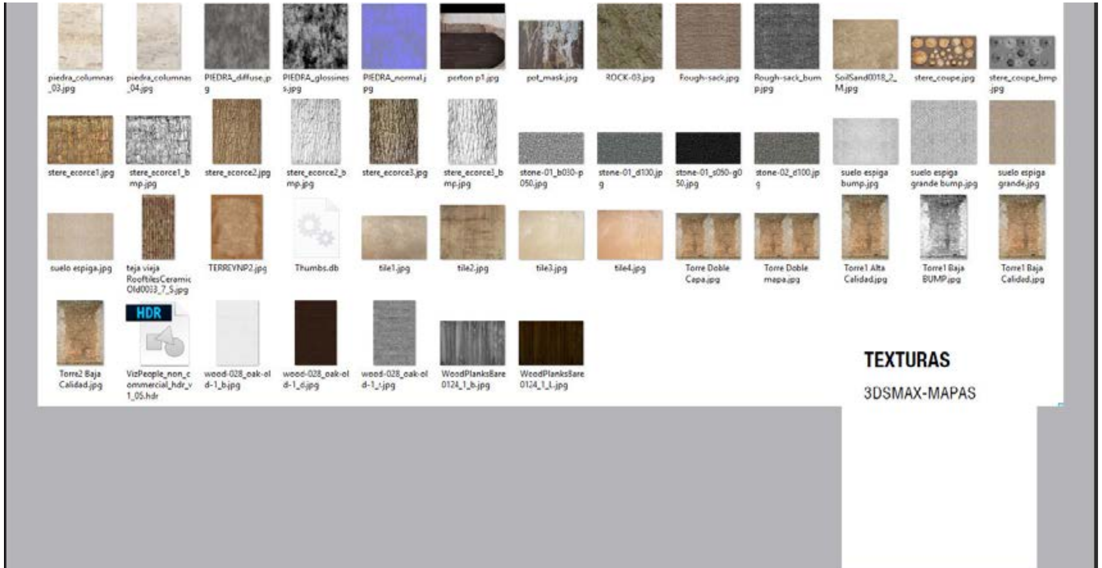

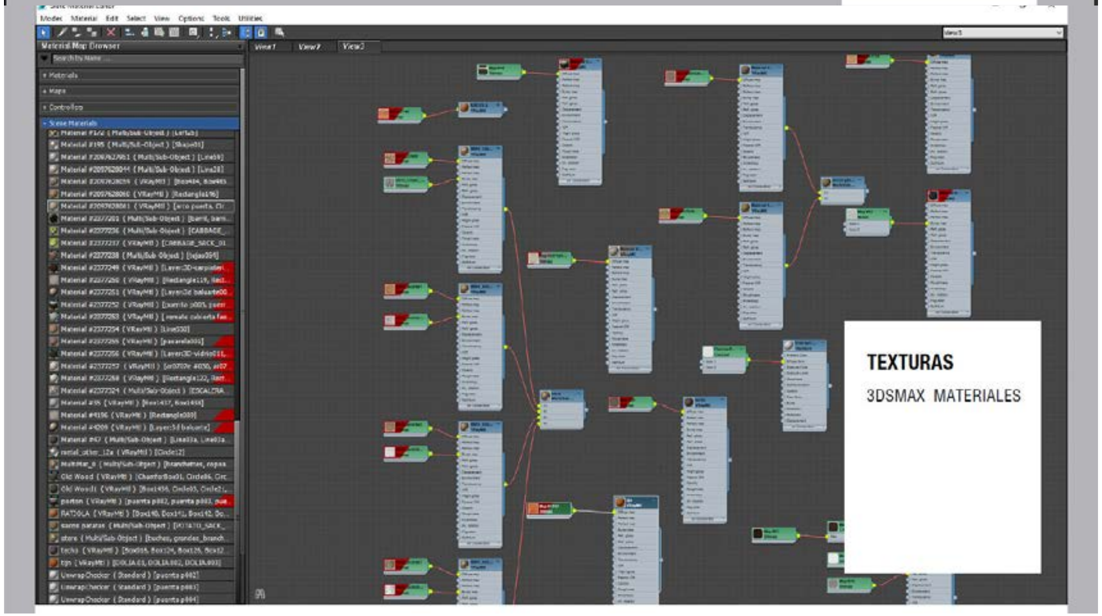

they can even be used to recreate by means of virtual tours the sensory experiences that the original spaces could have transmitted. Each phase of work must undergo an iterative process, which allows to improve its results in order to advance the investigation.
The application of information technology and the production of scientific virtual models do not structurally alter the architectural asset, but they do contribute to improving its documentation, overcoming barriers with respect to archaeological findings and disappeared historical heritage. This is why we consider virtual models to be especially useful in the field of heritage documentation, and they also facilitate public promotion, contributing to increasing their heritage value (Máñez Pitarch & Garfella Rubio, 2019). Advances in digital graphics have made it possible to increase the realism of virtual representations, facilitating the undertaking of precise studies on constructive and typological methods.
The use of a digitized model in the first instance allows a closer and more accessible vision of the complex for all publics from the visual perspective, given that this new form of representation is more mimetic and intelligible than any of the two-dimensional graphic tools traditionally used by architects and archaeologists. Moreover, these graphic techniques make it possible to represent models that are more conceptual and offer not only more realism and details, but also more analysis content, improving understanding of the constructive evolution of the architectural object.
Today, intelligible, universal languages are necessary to allow society to know and appreciate its history, and people actively seek out means of communication that can offer them knowledge in an immediate and attractive manner.

Fig. 16 - Textures used for the rendering.

Fig. 17 - Textures used for the rendering.

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Virtual tours allow viewer and heritage to interact with each other (Fig. 19). Digital models that can support the arts, tourism and culture sectors go beyond the simple 3D representation of digital space. These systems are increasingly joining and integrating with social platforms, education and entertainment. But it must be said that virtual and augmented reality (VR-AR) are still developing research fields in the digital cultural heritage sector (Banfi, 2021).
The creation of virtual models that can be explored in real time takes us another step forward, because it is in truth a matter of recreating an architectural space, a simulation that is as close as possible to what a real experience would be, making it possible to expand your perception by means of the digital vision of the reconstructed architectural space and the ability to move around within it.
In the case described here, interdisciplinary research has resulted in the construction of a virtual model of the Monastery of Santa Maria de la Murta. It has served as the base for various studies on the structure of the vaults of the nave of the church and of the behaviour of the acoustics of the nave and, in the final phase, the recreation of a virtual tour inside the nave of the church.
We would like to emphasise the importance of disseminating the output of scientific research. First, to the scientific community, based on the publication of articles in specialist media. And second, efforts have been made to reach the widest spectrum of the public using accessible formats to increase both their appreciation of the asset and their awareness of the need to protect it. The final video was presented at Alzira City Hall and is available to be viewed on the municipality's website (https://www.facebook.com/MUMAMuseuMunicipalAlzira/videos/v%C3%ADdeo-murta-2018/970917149746859/).

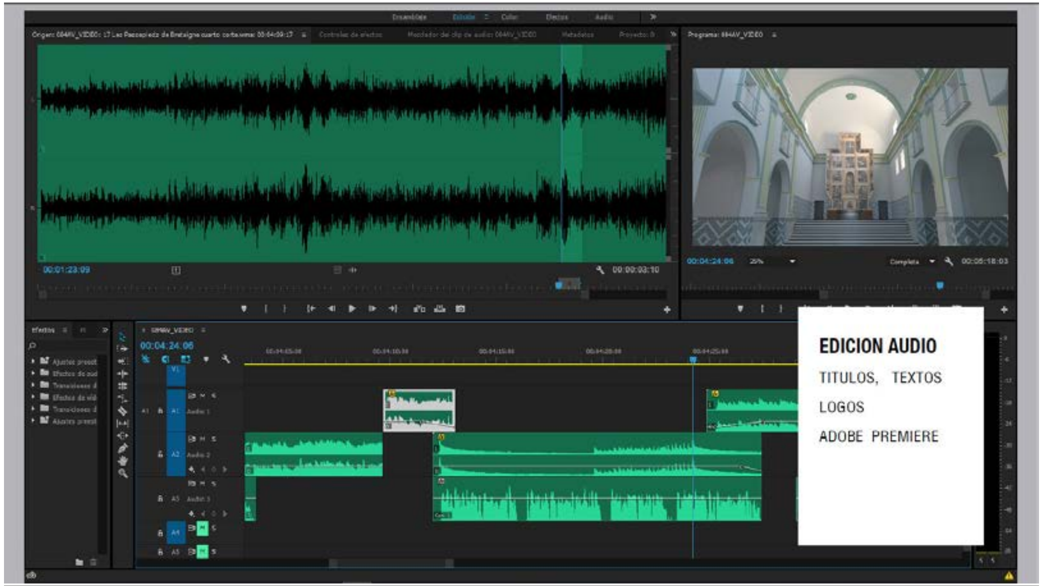

Fig. 18 - Image of the audio and video editing process.

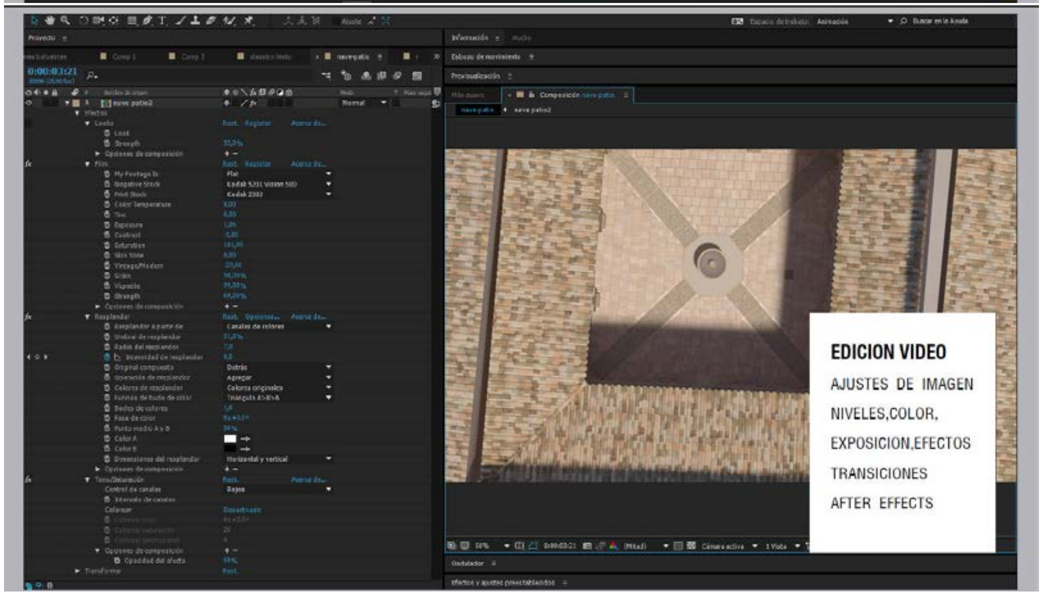

Fig. 19 - Image of the audio and video editing process.

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We can summarise the advantages and improvements of the virtual reconstruction of disappeared heritage architecture as follows:

1. It is an up-to-date method (in line with the multimedia world of our times) of documenting and highlighting the values of heritage that has either disappeared or is at risk.
2. The graphic realism of the reconstruction based on scientific methodology and the technological component of these multimedia techniques spark the general interest of society.
3. The non-specialist public can see with their own eyes what the heritage site they are visiting was like in the past. The experience is better and more immersive than those using traditional resources.
4. It is a sustainable, economic and non-invasive technique, given that it does not require any intervention in the heritage element.
5. It is an interpretation of the heritage that can be reviewed at any time, built on and continually evolved.
6. It generates content adaptable to all types of dissemination tools, especially those based on new technologies, increasing the interest of all types of publics, thereby helping raise collective awareness about the importance of appreciating disappeared heritage.

NOTE

[1] For example, Fornés Gurrea, to close the lunettes in barrel vaults recognised the geometric complexity of the intersection of the two surfaces and recommended closing them ‘by means of an arch-shaped centring board, with a short sagitta, at the discretion of the artist’, that is, not necessarily adhering to a rigorous geometry.

[2] “Continuum models represent widely used solutions for the structural analysis of masonry buildings. Concerning direct approaches, isotropic smeared crack and plastic- damage constitutive laws have been widely used for the structural assessment of historic monumental structures. Indeed, these approaches often represent the only suitable strategy to deal with such complex structures.” (D’Altri et al., 2019).

REFERENCES

Alonso Durá, A. (2014). *ANGLE*. Valencia (Spain): Universitat Politecnica de Valencia.

Arciniega García, L. (1999). Santa María de la Murta (Alzira): Artífices, comitentes y la «Damnatio Memoriae» de D. Diego Vich. *La Orden de San Jerónimo y Sus Monasterios: Actas Del Simposium (I))*, 269–292. Retrieved from http://www.uv.es/arcinieg/pdfs/monasterio_de_santa_maria_de_la_murta_y_los_vich.pdf

Arciniega García, L. (2001). *El monasterio de San Miguel de los Reyes* (Biblioteca Valenciana, Ed.). Retrieved from http://bivaldi.gva.es/catalogo_imagenes/imagen.cmd?path=1000444&posicion=1

Banfi, F. (2021). The evolution of interactivity, immersion and interoperability in HBIM: Digital model uses, VR and AR for built cultural heritage. *ISPRS International Journal of Geo-Information*, 10(10). https://doi.org/10.3390/ijgi10100685

D’Altri, A. M., Sarhosis, V., Milani, G., Rots, J., Cattari, S., Lagomarsino, S., … de Miranda, S. (2019). Modeling Strategies for the Computational Analysis of Unreinforced Masonry Structures: Review and Classification. *Archives of Computational Methods in Engineering*, 27(4), 1153–1185. https://doi.org/10.1007/s11831-019-09351-x

Esclapés, J., Tejerina Antón, D., Esquembre Bebia, M. A., & Bolufer Marqués, J. (2013). *Propuesta metodológica para la generación de recorridos virtuales interactivos*. Retrieved from http://rua.ua.es/dspace/handle/10045/34868

López-Yarto Elizalde, A., Mateo Gómez, I., & Ruíz Hernando, J. A. (1995). El monasterio jerónimo de Santa María de la Murta (Valencia). *Ars Longa*, (6), 17–23. Retrieved from http://hdl.handle.net/10261/16161

Máñez Pitarch, M. J., & Garfella Rubio, J. T. (2019). The diffusion of architectural heritage, through social networks, as a digital heritage. *DISEGNARECON*, Vol. 12, pp. 41–417.

Perelló Roso, R. (2015). *Aproximación al comportamiento estructural de la iglesia y torre del monasterio de Santa María de la Murta* (Universitat Politècnica de València). https://doi.org/10.4995/Thesis/10251/57046

Ruiz Hernando, J. A. (1997). *Los monasterios jerónimos españoles*. Retrieved from http://oa.upm.es/10187/1/LOS_MONASTERIOS_DE_LOS_JERONIMOS_ESPAÑOLES.pdf

Sender Contell, M. (2014). *El Monasterio de Santa María de la Murta. Análisis arquitectónico de un Monasterio Jerónimo*. (Universitat Politècnica de València). https://doi.org/10.4995/Thesis/10251/37190

Sender, M., Planells, A., Perelló, R., Segura, J., & Giménez, A. (2017). Virtual acoustic reconstruction of a lost church: application to an Order of Saint Jerome monastery in Alzira, Spain. *Journal of Building Performance Simulation*, 1–22. https://doi.org/10.1080/19401493.2017.1340975

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