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The churches of Alto Gállego

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Abstract

The research focuses on the group of churches in the Alto Gállego region, north of the province of Huesca, known as "Iglesias del Serrablo". The uniqueness of the complex and its architectural value provide a very important asset to the architectural heritage of the area.

The "Amigos del Serrablo" Association, founded in 1971, has been valuing this heritage since its inception through its rehabilitation; however, the limited information and studies carried out on these properties mean that many of them are still unknown to the general public, despite the routes proposed by the Association for their dissemination.

The research that is being developed analyses this group of churches from different areas: geopolitical, historical, geographical, orographic, etc., and also provides an architectural study that helps technicians to address rehabilitation projects.

In order to develop the architectural analysis of the properties, a virtual model is created using tools such as a 3D scanner, drone flights and a camera; which, subsequently, through the application of techniques such as photogrammetry and point clouds, allow us to obtain the 3D model of the churches studied.

With the digital model of the church, the investigation will be approached in two lines: a more technical one in which the geometric documentation, lights, construction and structural elements, dimensions, etc., are analysed; that serves to establish hypotheses of virtual reconstruction of those churches that are in ruins, or that help to establish a line of action to rehabilitate. On the other hand, the digitisation of the building allows the creation of graphic representation support, such as virtual reality and augmented reality, that favours the dissemination and accessibility of this architectural heritage to a wider public, both in person and virtually.

Keywords: *3D Scanner, Photogrammetry, 3D Modelling, Digital Surveying, Virtual Reality, Augmented Reality.*

1. Introduction

The research focuses on the group of churches in the Alto Gállego region, north of the province of Huesca, currently known as "Iglesias del Serrablo", a name that derives from the term coined "Iglesias Mozárabes de Serrablo" by Julio Gavín Moya and Antonio Durán Gudiol to refer to "this group of churches as one of the hallmarks of the territory" (Gavín J.; Durán A., 1969). The uniqueness of the complex and its architectural value provide a very important asset to the architectural heritage of the area.

The "Amigos del Serrablo" Association, founded in 1971, has been valuing this heritage since its inception through its rehabilitation. However, the information and studies carried out on these properties mean that many of them are still unknown to the general public.

The study of the churches as a whole has been approached from different points of view, from the field of history, geography, geology, sociocultural aspects, etc., but studying them from an architectural point of view is a good opportunity to be able to approach them as a line of research that allows analysing the entire set of churches and the effect that it had at the time of construction, as well as finding common elements that help us graphically reconstruct those that are not in a good state of conservation.

This set of churches was built in the Middle Ages, between the 10th and 12th centuries, and is made up of buildings in the Mozarabic and Romanesque styles, with Visigothic elements as well. The churches share common elements that homogenise the group and relate to each other throughout the territory (Gavín J., 1969); however, they present singularities that make some associate more with one architectural style than with another under the point of view of art historians who have studied these styles (Figures 1-2).

Figure 1. Lárrede church. Source: Muñoz, C. (2023).

Figure 2. Gavín church. Source: Muñoz, C. (2023).

The territorial, economic and temporal context of the churches makes this complex of special interest, since we must understand that they were built in the early stages of the Middle Ages in small municipalities, far from large population centres, with little economic capacity. to be able to tackle such important undertakings as the building of a church, much less so many churches in such a close territorial area; and in a context of wars for dominion and control of the territory.

In addition, the set of churches is distributed along the route of the Gállego River (Figure 3), with a changing and heterogeneous geography, with depressions and elevations that make it difficult to transport materials, which do not allow a visual relationship between the majority of them despite their physical proximity (Figure 4).

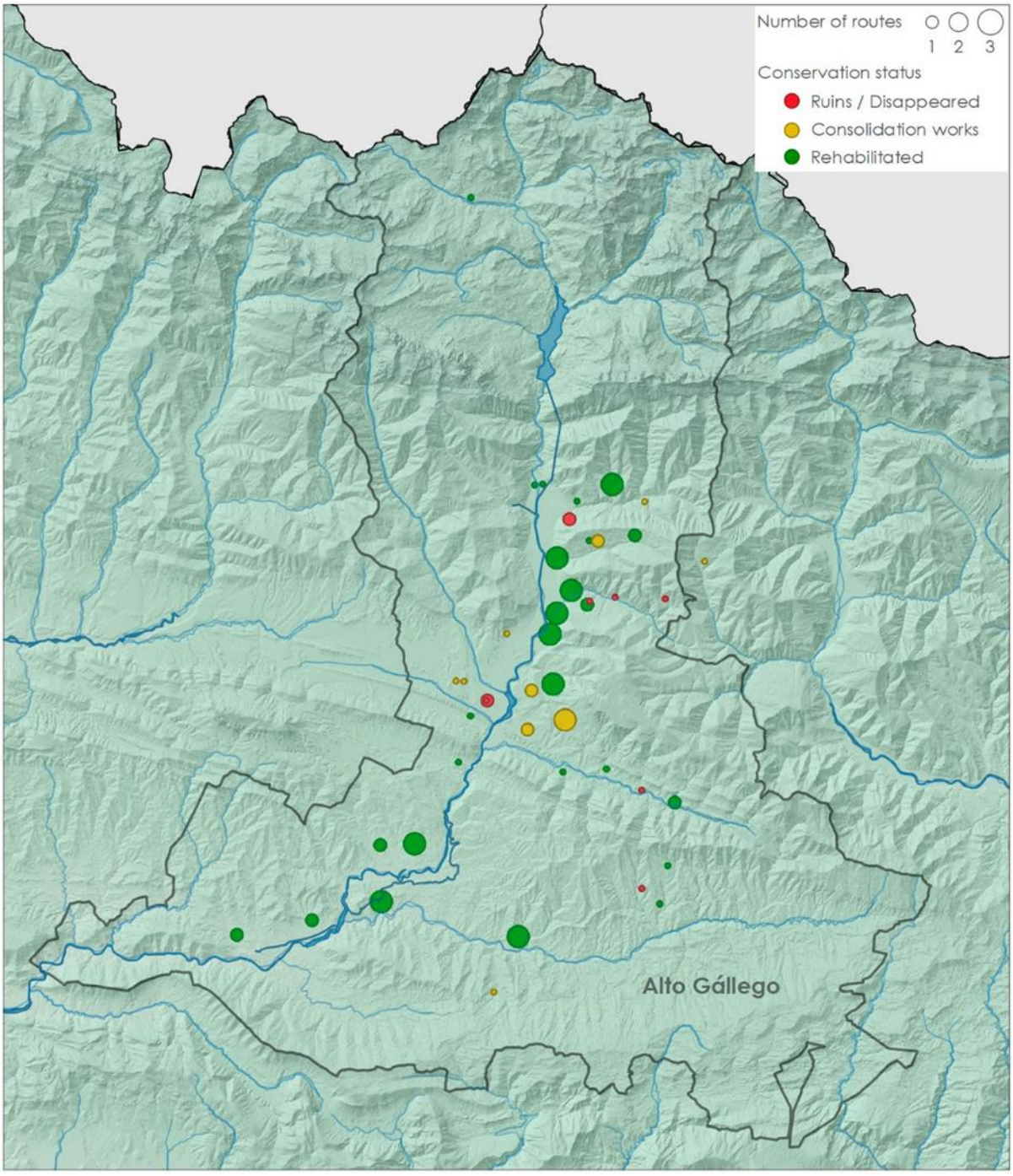


Figure 3. Serrablo churches map. Source: Muñoz, C. (2022).

"The upper basin of the Gállego River is a space of great landscape diversity, with mountains, glaciers, rivers and lakes; to these physical and climatic peculiarities must be added its border character, its isolation, its unity and its autonomous organization as the support of an interesting and long history"
(Biarge F. & Biarge A., 1999, p.2)

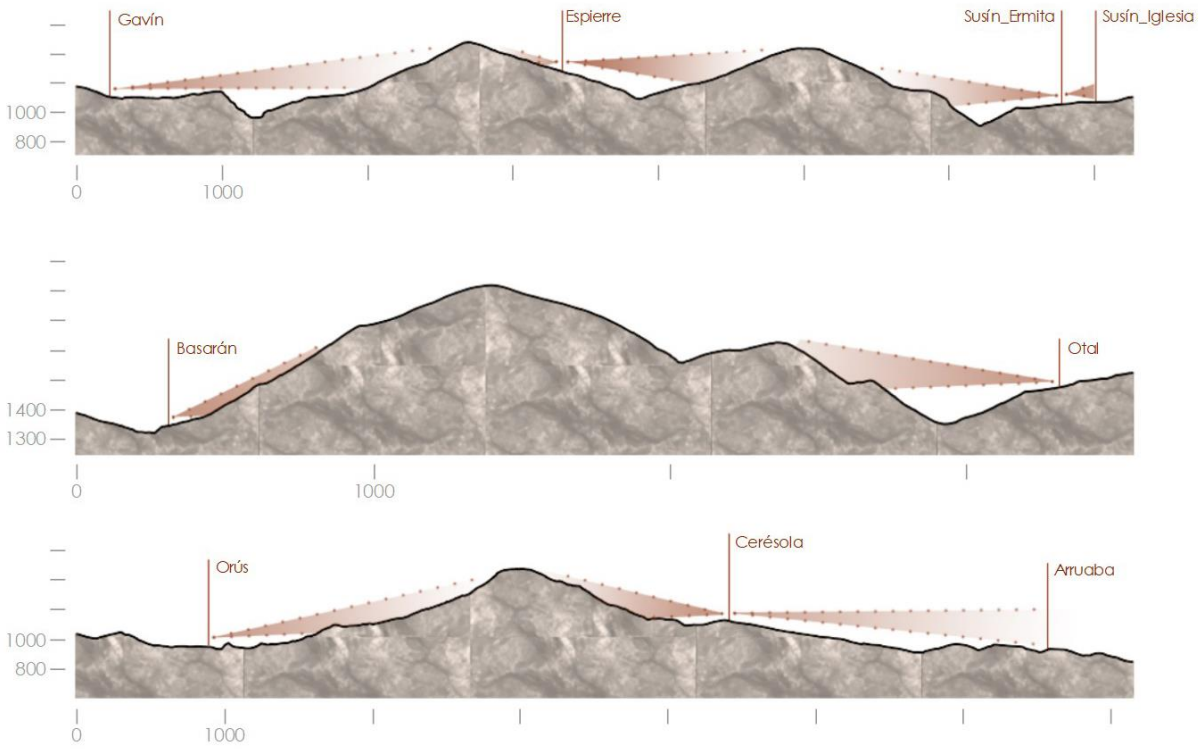


Figure 4. Terrain sections. Source: Muñoz, C. (2022).

2. Aims and objective

The main objective of the research is to revalue the architectural heritage found in this place by increasing its dissemination and accessibility while analysing more technical aspects focused on professionals in the sector. To achieve this, two lines of work have been established that complement and contribute to each other.

On the one hand, analysing the set of churches from a technical point of view allows us to establish hypotheses and conclusions that serve to relate and find common elements throughout the set with which to address future restoration, conservation and rehabilitation work carried out by the corresponding professionals.

On the other hand, it seeks to create a graphic representation support such as virtual reality and augmented reality that favours the dissemination and accessibility of this architectural heritage, both in person and virtually.

Photogrammetry techniques combined with the corresponding software are the vehicle that allows the construction of digital models of the churches with which to analyse and extract the construction, spatial, geometric characteristics, etc., in addition to adding elements of interaction, information and visualisation that help us achieve the aforementioned objectives.

3. Methods and procedure

3.1. Study work

The research is structured in different stages that provide information that is related to each other, which is why they are not closed work blocks with a defined beginning and end, but rather they support and provide data between them.

The first block focuses on studying and analysing all the written documentation about the churches, addressing different contexts, whether it is an anthropic context such as historical, social, economic, cultural, etc., or it may

be a natural context such as orographic, geographical, geological, etc. As well as, the study of the graphic and digital context on the representation and cataloguing of architectural heritage. (Figure 5).

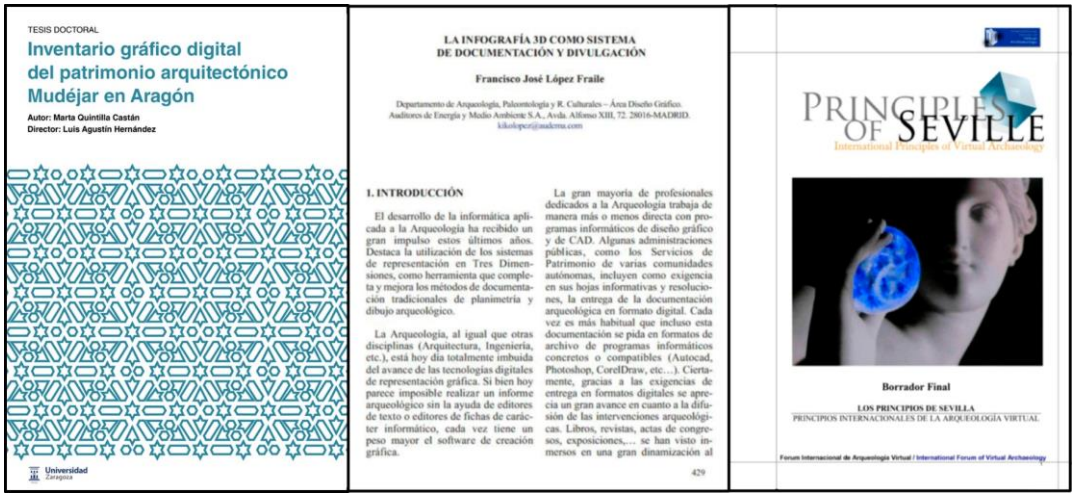
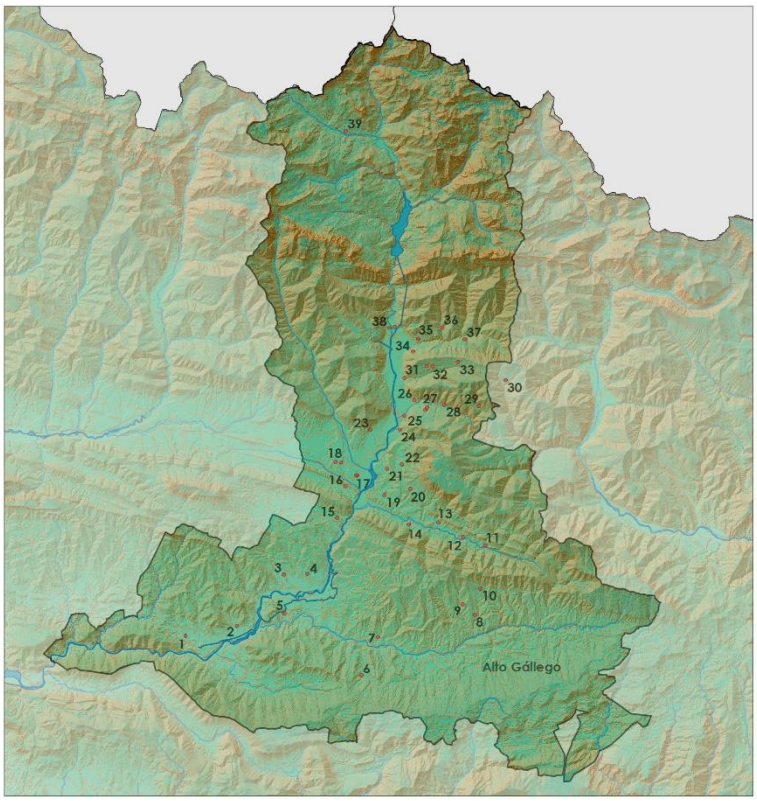


Figure 5. Books and articles for context. Source: Muñoz, C. (2023).

For the analysis of the analysed contexts, a study was carried out of the documentation available both in physical and digital format of each church, books related to the churches, their history and the Serrablo area, scientific articles from other researchers that explain the popular and religious architecture of the area, the history of the kings who had governed those territories at the time of the construction of the churches, etc. (Figure 6).

Figure 6. Books and articles for context. Source: Muñoz, C. (2023).

Another block of study of the Churches is developed prior to fieldwork. It involves the identification, geolocation, classification and documentation of each of the churches that are part of the complex being investigated. To do this, a list is prepared to indicate all the churches or hermitages located in the research area that are part of the group of churches with similar characteristics that can provide that character of unity (Figure 7).



Catalogue of Serrablo churches

Region of Alto Gállego

1	Javierrelatre	Iglesia de la Adoración de los Santos Reyes
2	Latre	Iglesia de San Miguel
3	Orna de Gállego	Iglesia de San Miguel
4	Arto	Iglesia de San Martín
5	Lasieso	Iglesia de San Pedro
6	Belarra	Ermita de San Ramón
7	Ordovés	Iglesia de San Martín
8	Arruaba	Ermita de Santiago
9	Artosilla	Iglesia
10	Cerésola	Iglesia de la Purificación
11	Orús	Iglesia de San Juan
12	San Julián de Basa	Iglesia
13	Yebra de Basa	Iglesia de San Lorenzo
14	Allué	Iglesia de San Juan Bautista
15	Rapún	Iglesia de San Félix
16	Sabiñánigo Alto	Iglesia de San Hipólito
17,1	Sabiñánigo	Ruinas iglesia de Santa María de Gavín
17,2	Sabiñánigo	Ruinas iglesias y ermitas de Castiello de Guarga, Arasilla y Aineto
18,1	Cartirana	Iglesia de San Martín
18,2	Cartirana	Ermita de Santa Lucía
19	Sardas	Iglesia de Santa María
20	Isún de Basa	Iglesia de Santa María
21	Latas	Iglesia de San Martín
22	Satué	Iglesia de San Andrés
23	Sorripas	Iglesia de San Andrés
24	Lárrede	Iglesia de San Pedro
25	Lárrede-Oliván	Ermita de San Juan de Busa
26	Oliván	Iglesia de San Martín
27,1	Susín	Ermita de Nuestra Señora de las Eras
27,2	Susín	Iglesia de Santa Eulalia
28	Oliván	Iglesia de San Pedro
29	Basarán	Iglesia de San Miguel
30	Otal	Iglesia del Nacimiento de Nuestro Señor Jesucristo
31	Orós Bajo	Iglesia de Santa Eulalia
32,1	Espierre	Iglesia de San Esteban
32,2	Espierre	Ermita de Santa María
33	Espierre	Ermita de San Juan
34	Gavín	Monasterio de San Pelay
35	Gavín	Iglesia de Santa María
36	Gavín	Iglesia de San Bartolomé
37	Yésero	Iglesia de San Saturnino
38,1	Biescas	Iglesia de San Pedro Apóstol
38,2	Biescas	Iglesia de El Salvador
39	Formigal	Ruinas iglesia de San Miguel de Basarán

Figure 7. Catalogue of Serrablo Churches. Source: Muñoz, C. (2022).

At the same time, some cards were made that complement the list and serve as a catalogue of the churches that make up the group studied in the research. For this, the "QGIS" software was used to prepare the graphic material of the cards, and that also allows to have the information of each georeferenced church (Figure 8).

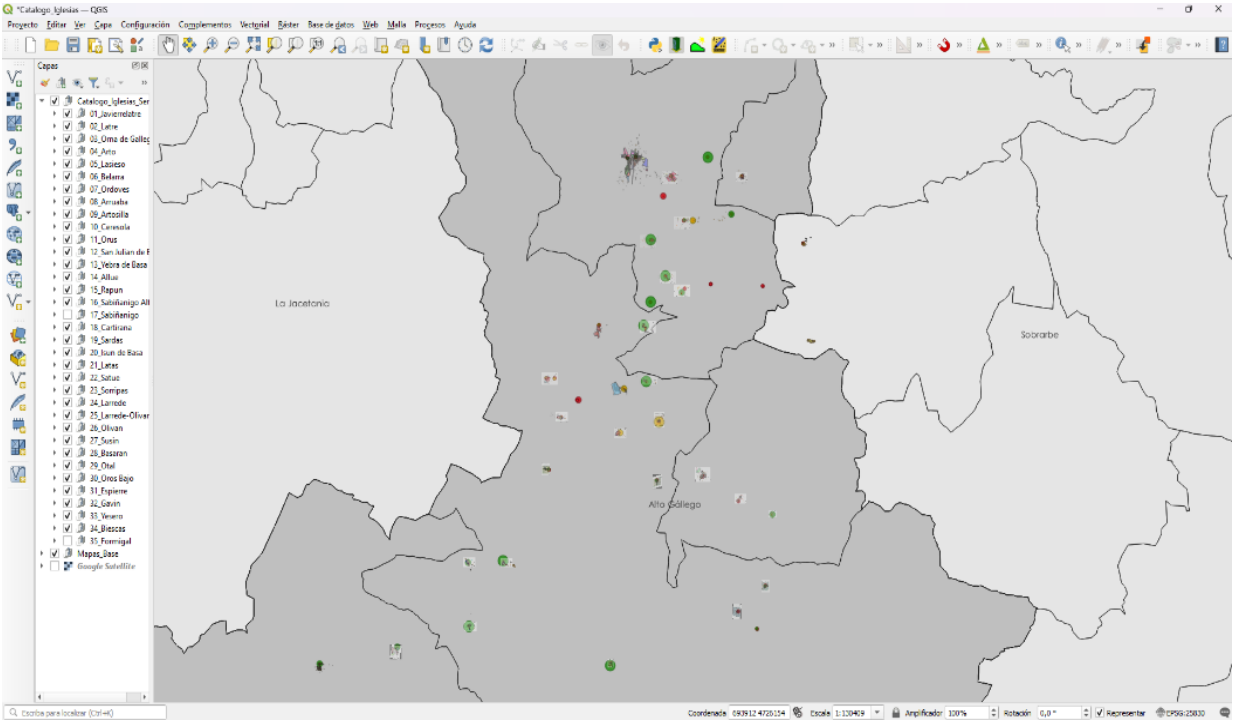


Figure 8. Geolocation of churches with QGIS. Source: Muñoz, C. (2022).

The files contain and graphically summarise the information obtained from the cadastre and the General Urban Planning Plans of each municipality; in this way, we can know the type of use of the plots, the classification of the land, if the church is protected by Heritage organisations, etc. also allowing a comparison to be established between them and also an example of cataloguing this type of property (Figure 9).

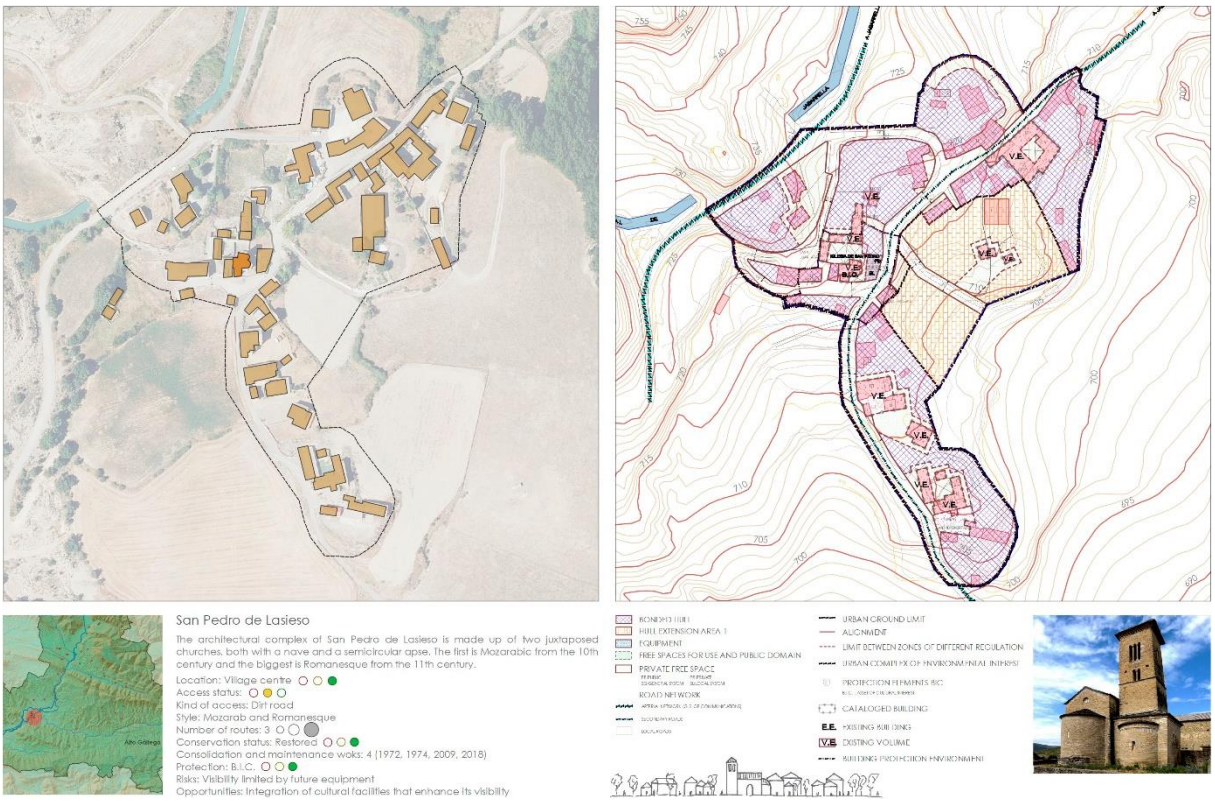


Figure 9. Type sheet of the Churches catalogue. Source: Muñoz, C. (2022).

Subsequently, with this catalogue of the churches and their corresponding files, a series of selection criteria is established (Table 1) based on the characteristics of the churches that will be used to make the decision to limit the number of samples to carry out the work of the field of research by reducing data collection to the most representative churches based on these selection criteria.

Table 1. Selection criteria

Artistic	Technical	Divulgation
Architectonic style	State of conservation	Number of visitors
Compositional elements	Number of interventions	Number of tourist routes
Proportions and morphology	Heritage protection level	Accessibility and location
	Construction elements and materials	

3.2. Fieldwork

Once the previous analysis has been carried out, we proceed to the individual study of the selected churches through in situ fieldwork whose work tools and procedures are the subject of this article. A digital survey of the selected churches will be carried out using different tools and devices.

On the one hand, prior to the visits, sketches of the property are made to serve as a basis for taking measurements that will help in checking the dimensions and scaling of the virtual models obtained. For this purpose, commonly used manual devices such as cameras, flexometers or laser meters are used. On the other hand, to obtain virtual models through point clouds, specific devices are used, such as 3D scanners, poles for remote access of photographic cameras, and drone flight by authorised personnel.

4. Results

After carrying out the fieldwork in the selected churches and obtaining all the necessary data from the on-site visits, we proceeded to process all the graphic information obtained.

Firstly, all the digital information obtained during the visit is downloaded, stored and organised in such a way that you can have quick and accurate access to the data needed at all times.

Subsequently, the photographs are processed using the *"Metashape"* software, specific for photogrammetry work. To do this, the coincident key points are identified in several photographs that allow us to relate the different positions of the camera in the process of virtual reconstruction of the church, obtaining a sufficient region to show us the church in its volume and textures.

After obtaining the point cloud of each church by processing the set of photographs taken in situ, the information is post-processed, that is, the selection of the points that we will use, as well as the discarding of those points that do not provide the digital model with the information that we want to obtain because they are not part of the scanned church. Once the point cloud with which we will work has been defined, we proceed to create the mesh and the rest of the elements that will be used to obtain the digital model of the church, such as the textures of the materials. Before finishing the process, the modelling must be cleaned, consisting of closing any possible gaps that the mesh created from the point cloud could not generate. (Figure 10)

Figure 10. Virtual reconstruction process of the model with photogrammetry. Source: Muñoz, C.; Piedrafita, J. (2015)

The same process of virtual reconstruction of the model will be applied to objects of special interest in the church environment. With the aerial images, we can create the exterior volume of the church, but the small details of the entrance porches, details of the bell tower, etc. They will not have the same presence as if we carry out these elements in detail with our own photographic scan for each element that we want to take out with a greater definition of detail (Figure 11).

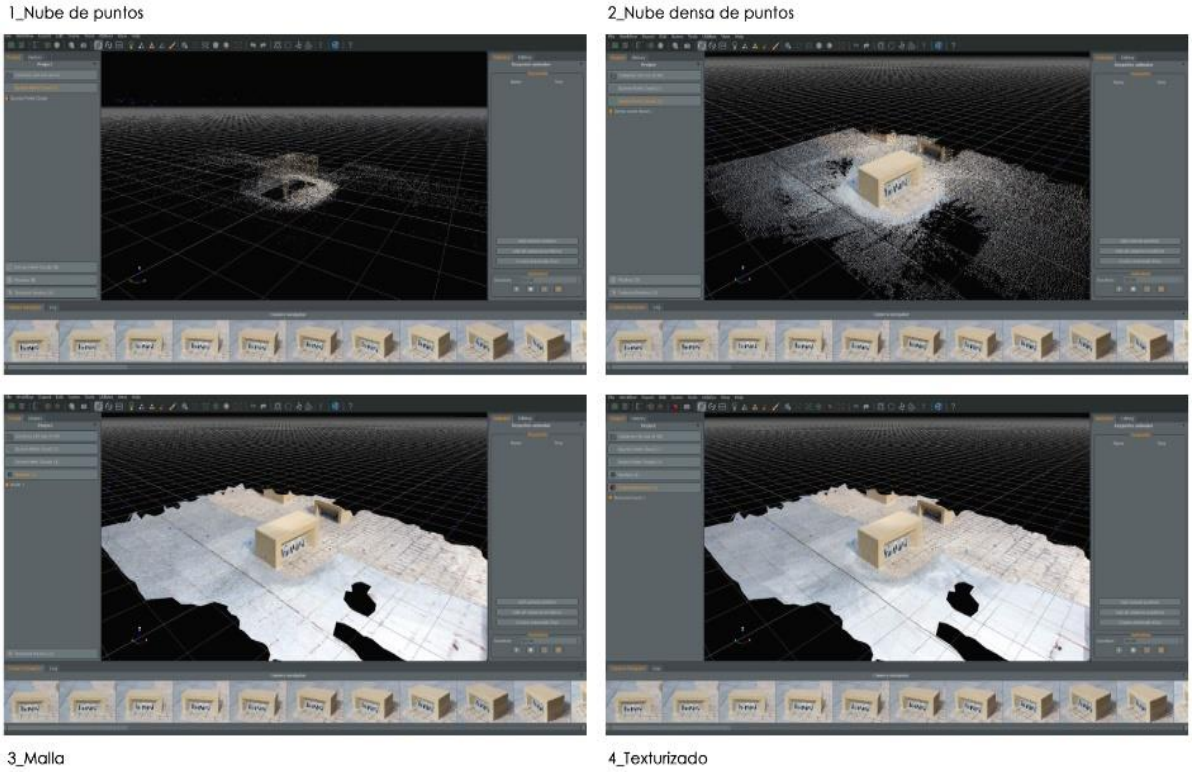


Figure 11. Photogrammetry of other elements. Source: Muñoz, C. (2022)

By processing the images taken during the visit to the church, either with the cameras or with the drone flight, a cloud of points of the exterior of the church is obtained. By processing the information obtained with the 3D scanner, we will obtain a cloud of points inside them.

To ensure that the proportions of the 3D modelling are correct, it is at this moment that we must check the dimensions of some of the elements, such as the length of the facades or of some of the openings, etc. This verification must correspond to the measurements that we have taken during the visit and that were noted in the sketches prepared previously; in this way, we will have a virtual model of the church correctly sized and geolocated to be able to work with it (Figure 12).

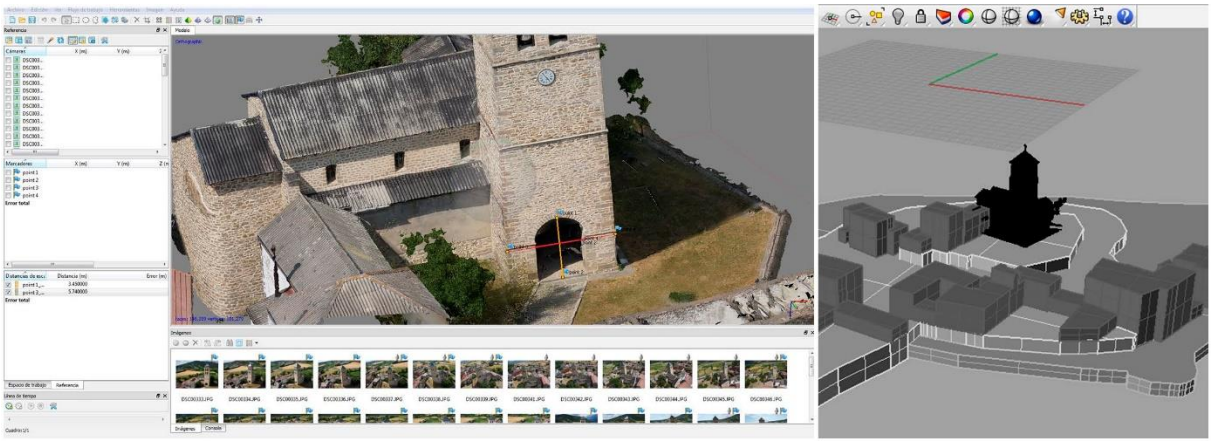


Figure 12. Virtual reconstruction of the church. Source: Muñoz, C.; Piedrafita, J. (2015)

Once the digital model of the church generated from photogrammetry has been created, we can obtain the 3D modelling in the usual format extensions to be able to work with it later. To do this, we must export both the mesh and the texture created in the format compatible with the 3D modelling program with which we are going to work.

You can also export the model in formats compatible with 2D drawing programs such as *"AutoCAD"* to be able to work with this information to prepare plans that serve to facilitate a possible intervention.

On the other hand, the correctly textured digital model allows us to create photomontages combining the real environment of the church with the virtual church with hardly any difference or be able to make other more creative photomontages focusing attention on the church and leaving the rest of the environment as volumes (Figure 13).

Figure 13. Volumetric photomontage with virtual church. Source: Muñoz C.; Piedrafita, J. (2015)

Finally, this virtual model of the church obtained will allow us to create a graphic representation to support the development of an interaction through virtual and augmented reality that helps disseminate the heritage that was proposed with the line of research.

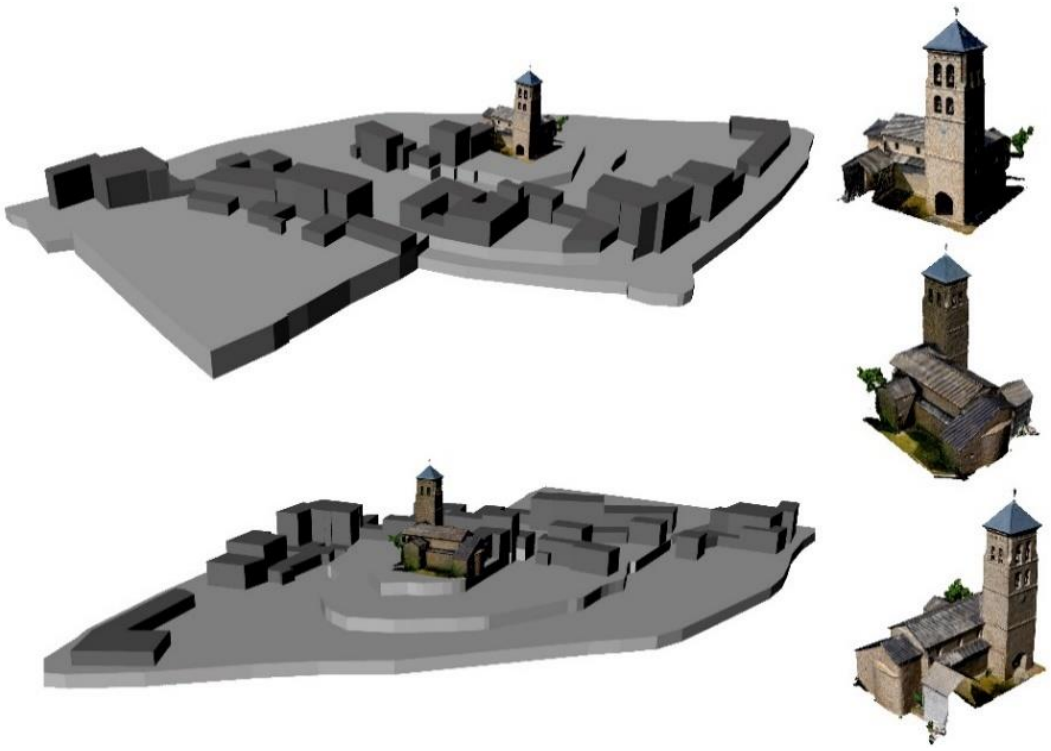


Figure 14. Virtual model of the church. Source: Muñoz, C., Piedrafita, J. (2015)

5. Conclusions

Photogrammetry tools have been used as a vehicle to obtain a digital model of the churches that are the object of the research in development and allow us to analyse their construction, architectural, volumetric and dimensional elements in order to establish a series of hypotheses about the common characteristics that define the group of buildings of the Alto Gállego churches.

On the other hand, the construction of a virtual model of the churches also allows the promotion of their dissemination digitally, helping to value the architectural heritage that this complex contributes to the territory, being able to bring the churches closer to a larger public through virtual visits, with the implementation of virtual reality and augmented reality that we will address in the final stage of the research, making these virtual visits an interactive and immersive experience with explanations, informative notes, etc.

In general, photogrammetry allows us to virtually reconstruct buildings that are part of our heritage; either to understand, analyse and delve into its construction process or to promote accessibility to its dissemination. Tragic events such as what happened in 2019 at Notre Dame de Paris or recently in 2024 at the Copenhagen Stock Exchange led to a serious deterioration of the architectural heritage of the place. The virtual reconstruction of these buildings through techniques such as photogrammetry allows us to have a basis of graphic, spatial, volumetric and technical information that helps the subsequent intervention to reconstruct the heritage. Likewise, new representation techniques such as virtual reality or 3D modelling allow us to visualise and interact with a building in ruins or with the result of the intervention in a heritage building prior to this.

6. References

Biarge F. & Biarge A. (1999). *Arquitectura popular, civil y religiosa. Valle de Tena y Tierra de Biescas* (1st ed.) Plan de Excelencia Turística Valle de Tena – Biescas

Buesa Domingo J. & Durán, A. (1981). *Guía monumental de Serrablo* (1st ed.) Amigos del Serrablo

Garcés, J., Gavín, J. & Satué, E. (1991). *Arquitectura popular de Serrablo* (2nd ed.) Diputación de Huesca, Instituto de Estudios Altoaragoneses

Gavín J.; Durán A. (n.d) *Asociación Amigos del Serrablo*. https://www.serrablo.org/

Muñoz, C. (2022). Academic work for *Cartographic Methods for the city and the territory*. Escuela de Ingeniería y Arquitectura, Universidad de Zaragoza. https://zaguan.unizar.es/record/104913/files/guia-30758-en.pdf

Muñoz, C. & Piedrafita, J. (2015). Academic work for *Representación Gráfica del Patrimonio*. Escuela de Ingeniería y Arquitectura, Universidad de Zaragoza. https://zaguan.unizar.es/record/115696/files/guia-30749-en.pdf

Satué, E. (1991). *Religiosidad popular y romerías en el Pirineo* (1st ed.) Diputación de Huesca, Instituto de Estudios Altoaragoneses