View from the square, of the City Council and Lonja of Alcañiz (Teruel)

3D survey and virtual reconstruction of heritage. The case study of the City Council and Lonja of Alcañiz

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Abstract: With current data acquisition techniques, exhaustive documentation of patrimonial goods is generated, which allows obtaining a 3D geometric model, on which data from research from research is generated. As in other fields of architecture, the latest graphic techniques and manipulation of the image, allow a working methodology other than the current one in the patrimonial field. The information systems have been evolving towards technologies developed with open source software, the use of standards, ontologies and the structuring of information and of the 3D model itself under a semantic hierarchy. Interoperability between databases is favored and the maintenance of applications is ensured. The purpose is to support decision-making related to the model and simultaneously, serve multiple purposes such as cataloging, protection, restoration, conservation, maintenance or dissemination, among others. The research carried out for the realization of the survey of the City Council and Lonja of Alcañiz (Teruel), has the aim of expanding the historical knowledge of the buildings and delimiting its possible constructive phases, in order to obtain the geometric reality of the buildings. In this way, provide greater instruments to carry out the drafting work of the set restoration project.

Keywords: Cultural heritage; HBIM; Information systems; 3D Model; Survey.

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1. Introduction

In the area of historical heritage there has been a great rapprochement between restoration and new technologies in representation. This has caused that the documentation established in a traditional way, such as plans or photographs, is complemented with a spatial and virtual representation of the object. The benefits obtained are so numerous that at present the restoration of heritage assets entails the obligation of obtaining a 3D model, which will allow data from the investigation to be dumped into it. This requires the use of geometric information capture techniques such as photogrammetry and 3D laser scanning. Once the data have been obtained using survey techniques, the next step is to determine the type of product to be achieved, in order to display the information in the most appropriate way for specific needs. As in other fields of architecture, the latest graphic techniques and image manipulation allow us to consider a different work methodology from the current one in the heritage field. These changes, in turn, imply an evolution in the products obtained as a result of the capture, since they make it possible to generate more documentation with great precision that must be stored and managed efficiently, quickly, accurately and without loss of information.

In order to become an effective tool for the different technicians involved in heritage along the life cycle of the building, as architects, archaeologists, historians, engineers or curators, 3D models must be able to store different types of information in multiple formats and, hence, to record their material and cultural values. Therefore, the use of a common data model facilitates the interoperability and accessibility of the archived information and its use by different actors for multiple and varied uses, which, according to Schuster (1997), can be: identification and documentation; knowing its existence and documenting its status; evaluation, noting its importance; recognition, promotion; restoration and conservation techniques, documenting deterioration processes; coordination between the different agents with responsibilities; education; persuasion.

The compilation, classification, analysis and presentation of the information requires the use of protocols to order and use in a comprehensible and coherent way the graphic documentation necessary to preserve the conservation of the architectural heritage. The modeling of the information obtained, allows an exploration of the elements by construction phases and document all the architectural pieces with great precision of the geometric information. The proper record of these relationships, as well as the correct definition of the materials and construction systems of the historic building, become basic requirements of the graphic documentation, since it supposes the safeguarding of a good part of its material cultural values. The information included in the parameters will be available to other researchers who need to access it during the life cycle of the building, for analysis and diagnosis in subsequent interventions.

The evolution of architectural heritage documentation has undergone significant updates and improvements, thanks to the use of technologies that allow information to be stored in the same HBIM (Historic Building Information Modeling) model. BIM technology is capable of incorporating information on a stratified support in order to obtain a complete vision of the building, incorporating useful information for its conservation, restoration, protection and dissemination. It is like this, thanks to the visualization, documentation and management capabilities, as well as the interoperability between tools and other systems throughout the entire life cycle of the building.

2. Methodologies for the virtual reconstruction of heritage

Traditionally, the information that represented the architectural heritage was composed of plans, photographs and texts, in two-dimensional format. But, with the evolution of representation systems, their transformation has been linked to computer development. With current data acquisition techniques, exhaustive documentation of heritage assets is generated, that allows the obtaining of a 3D geometric model, on which to dump data from the investigation. This situation implies new challenges, such as the storage and accessibility of information in an easy and intuitive way.

Historic buildings are the result of a series of constructive, destructive and transformative actions that have taken place throughout their history. The current state of a building is what it offers at a precise moment in its history, and to know it, we must provide the theoretical framework that allows its evolutionary vision to be rigorously documented. For this, it is necessary to activate an interdisciplinary analysis process that allows coordinating and pooling the analysis processes and workflows (Armisén et al., 2018). Obtaining a complete 3D virtual model of the architectural heritage has been a great effort for numerous researchers, whose methodological proposals focus on the use of BIM technology.

One of the first examples to review is the NUBES platform (De Luca et al., 2011), whose main characteristic is the incorporation of the space-time function to the virtual representation of the object It is based on the changes suffered by the buildings over time, since they are not constant forms, due to the modifications suffered or even the disappearance. The capacity for simultaneous visual navigation in space and time thanks to the semantic structuring, allows querying and analysis, by means of visual comparison in terms of the distribution of temporal space.

It should be noted H-BIM, a methodology developed for the construction of a library of interactive parametric objects, in order to obtain complete 3D models that include details of materials and construction methods. Methodology used for the elaboration of objects based on the Vitruvian treatises (Murphy et al., 2013) or for the modeling of Four Courts in Dublin (Dore et al., 2015).

Some of the current BIM programs have been designed to model new construction buildings, therefore, they lack 3D objects and adequate tools, specific for their use in architectural heritage. Historic buildings are unique, in most cases processes that lead to the standardization of construction elements cannot be applied to them. In particular, when working with point clouds, NURBS (non-uniform rational B-spline) cannot be used and instruments capable of automatically extracting geometric primitives from sections are required.

To solve this need, some authors (Banfi, 2019) have begun to work with the idea of adapting the different modeling programs for use in heritage. Thanks to the availability of APIs (Application Programming Interface), add-ins have been designed to extend the native capabilities and features of the software. Obtaining benefits such as facilitating the import of point clouds, the integration of GOGs (Grade of generation) in the software architecture, facilitating the modeling of historical elements, automating the generation of databases, allowing the addition of new custom parameters and, lastly, the possibility of sharing the HBIM model data with other sources, external databases and BIM cloud platforms, maintaining a bidirectional relationship between the object and the information.

Furthermore, proposals have been made to create an Information Model of the Architectural Heritage, such as those developed for the Jail of the Royal Tobacco Factory of Seville (Nieto et al., 2014) or the Carlos V Gazebo of the Real Alcázar of Seville (Nieto et al., 2016). Both systems have been created to carry out a restoration project based on an HBIM model generated with Archicad and adapted to accelerate the automation and standardization of tasks, using instructions and algorithms programmed in API. In other cases, plugins such as Rhinoceros NURBS are used to represent architectural elements in detail, without excessive simplifications and thus avoid the problems related to the standardization of elements in objects and families, useless for conservation processes (Oreni et al., 2014).

Currently, commercial software is not completely adapted to the specific needs of heritage. There is a lack of an Integral System that includes the capabilities of modeling, storage, management and analysis, necessary to carry out intervention and conservation projects, but there are various projects focused on the development of specific software for architectural heritage.

To cover this need, specific programs have been developed for the representation of architectural heritage, such as BIM3DSG. It is an integrated system consisting of two parts, that integrates a complex 3D model on which all the necessary documentation for its management is incorporated. The system facilitates the import or modification of a complex 3D model by specialized or professional users. At the same time, it allows common users to use the system through a web environment, which favors accessibility and mobility, without additional costs. In addition, the system offers the possibility of adding information and files associated with the different objects that compose the model, such as images, videos, documents or cad files. In this way, it can be accessed through the constitution of user-defined entities, to all the information stored in a BIM model, totally or partially, allowing to choose its visualization between seven different levels of detail (Fassi et al., 2015). The application has been used during the restoration work of the Duomo in Milan (Rechichi et al., 2016) or for the conservation of the mosaics of San Marco in Venice (Fassi et al., 2017).

It is also worth to mention the European project INCEPTION, an open standard web platform developed to access, process and share 3D digital models created according to a semantic structure. They are the result of the realization of 3D surveys and data capture, focused on the management of patrimonial information. The interoperability of the platform is guaranteed by the integration of a glossary called H-BIM ontology, which uses the Art & Architecture (AAT) thesaurus from the Getty Institute to cover all the heritage nomenclatures that BIM programs do not include, as well as it allows to link the CIDOC Conceptual Reference Model (CRM) ontology. These characteristics give the platform great versatility to be used for multiple objectives, such as conservation, restoration or dissemination, since it allows adapting how the information is displayed depending on the user (Iadanza et al., 2019).

Developed specifically for the drafting of professional projects, the Petrobim application is capable of managing information regarding a heritage asset, throughout the entire life cycle of the building (Armisén et al., 2016). The program is composed by specific modules for the different levels of intervention and characteristic of each job, such as: 3D modeling, construction elements, construction materials, alterations, construction phases, humidity, deformations, intervention and maintenance. The program has numerous tools to operate with the model, especially, it facilitates the navigation and realization of graphical and numerical queries, applying selective filters. When working in a network, the information is updated in real time, accessible and centralized.

Summarizing, BIM information systems are capable of integrating all types of information and documentation. Its ability to interconnect with the web, and to solve the needs of interoperability and accessibility make its use proliferate in the field of Architectural Heritage (Afsari et al., 2016). This characteristic is common in all the systems shown, thanks to the use of semantic web standards, such as IFC / OWL (standard for BIM modeling in a semantic web language). It allows to share the information stored in an HBIM model to be accessible for consultation through a web platform. The use of semantic models facilitates a more effective use of resources and a higher visualization speed (Apollonio et al. 2011). The integration and support of cloud services improve the updating of information in real time, the ability to process and analyze large amounts of information in short periods of time and the use of desktop applications that only show the data processed (Marston et al., 2011).

3. Case study: City Council and Lonja of Alcañiz

3.1 Historical and documentary study of the buildings

In order to understand these two buildings and to perform an adequate documentary record, it is essential to carry out a previous historical-artistic study, that provides the necessary knowledge to know how to formally interpret the different construction stages that form the architectural complex.

Alcañiz's "City Council and Lonja" complex (Fig. 1) was declared a historical-artistic monument on June 3, 1931. At the present, it is an Asset of Cultural Interest of the Aragonese Heritage with the category of Monument (Thomson, 2015). Both buildings form a monumental and structural unit, including the Gothic-style Lonja and the Renaissance-style City Council. The main facades of the buildings create an angle of 103º to each other, forming a square influenced by the geometry of the perspective, like many public spaces in the Renaissance style, as opposed to the perpendicularity imposed by the geometry of the Gothic style.

The City Council building, completed in 1570, is in the Renaissance style, with clear Italian influence, but built before the publication in Spanish of the main treatises on Renaissance architecture (Vitruvio and Alberti in 1582, Vignola in 1593 and Palladio in 1625), so it is unprecedented that uses a refined classicist language. The main facade is composed of three bodies, in the style of classic Aragonese palaces, with a ground floor with a patio articulated with seven columns and access to the monumental staircase that leads to the noble floor. On the top floor there is a gallery with semicircular arches, singular of the noble Aragonese Renaissance architecture, which connects with those of the Lonja building. The main facade to the square is built in stone, while the lateral facade is finished in brick, following the Mudejar tradition.

The Lonja building consists of a large portico formed by three Gothic-style pointed arches and an upper floor that connects with the City Council building through a gallery. The building is conceived as an open loggia, in the style of the Florentines and Bolognese, differing from the closed Gothic markets of the Crown of Aragon, such as those of Palma, Valencia or Barcelona (Thomson, 2015).

From the 16th century to the present, the monumental complex has undergone important interventions, especially those carried out after the serious damage suffered in 1840 due to the explosion of a powder magazine, which affected the surroundings and other constructions of the square. In addition to the restoration carried out by Fernando Chueca Goitia between 1974-1979. Intervention that consisted in the consolidation of part of the facade of the Lonja and the opening of the openings of the arches of the upper gallery, eliminating the closing element that considerably disfigured the arcade (Hernández Martínez, 2016). Furthermore, in the 1980s a series of interventions were carried out, that involved a major transformation and expansion of the City Council and the dependencies linked to the Lonja. The successive reforms and interventions in the buildings, the continued exposure to the elements of the facades, as well as the nature of the stone have led to the deterioration of the buildings. As a consequence, it has been necessary to plan the intervention in the monumental complex, in order to ensure its preservation and restoration. For this reason, it has been necessary to carry out a graphic survey that would serve as support for the analysis of the current state of conservation and the studies prior to the drafting of the project (Fig. 2).

The survey work of the City Council and Lonja of Alcañiz (Teruel) was developed by the Architecture Research Group (GIA) of the University of Zaragoza. With

Figure 1 | Aerial view taken with drone of the City Council and Lonja of Alcañiz.

the aim of expanding the historical knowledge of buildings and delimiting their possible construction phases, so as to provide more information, by obtaining the geometric reality of the buildings. In this way, provide more tools to the architects in charge of carrying out the drafting of the restoration project of the complex. The work team to accomplish the investigation was completed with an archaeologist, a historian, a surveying company in charge of carrying out the geophysical study using geo-radar.

3.2 Capture and construction of the geometric model

Before the survey works, an investigation of the existing documentation of the building was performed in order to evaluate the authenticity of the elements, as well as the dimensional values to be recorded. After analyzing the data obtained, the necessary knowledge was acquired to proceed with the planning of the field work. This was structured in two phases, a first one that comprised data capture and building survey, and a second one involving cabinet work to obtain the volumetric model and incorporation of information into the BIM model.

The data collection was carried out in two campaigns over two weeks, in order to obtain a point cloud of both buildings. Six different coordinates are required to characterize the point cloud, three coordinates to indicate the position XYZ and the other three to define the colour, RGB values. The choice of the survey method to accomplish the data collection was carried out taking into account the type of building and level of detail required, therefore a combination of acquisition techniques such as laser scanner and photogrammetry was selected to obtain the complete model of the buildings.

In order to obtain photo-realistic textures and mapping, a Faro Focus 150 laser scanner was used, which allows an accuracy of ± 2 mm and a range of 0.6 to 130 m. A 6 mm density point cloud was obtained with volumetric and colorimetric information, which allowed the materials and paintings of the building to be recorded both from the interior and from the facades. Subsequently, a second data collection was performed by photogrammetry, using a Nikon F-810 photo camera and a focal length between 17 and 24 mm (wide angle). The photographic taking was completed with the one taken with a Phantom 3 drone, which includes a 12 megapixels camera and GPS that geolocates the photographs obtained. It facilitated the capture of data from the roof and the facades from a high point. The photogrammetric processing was carried

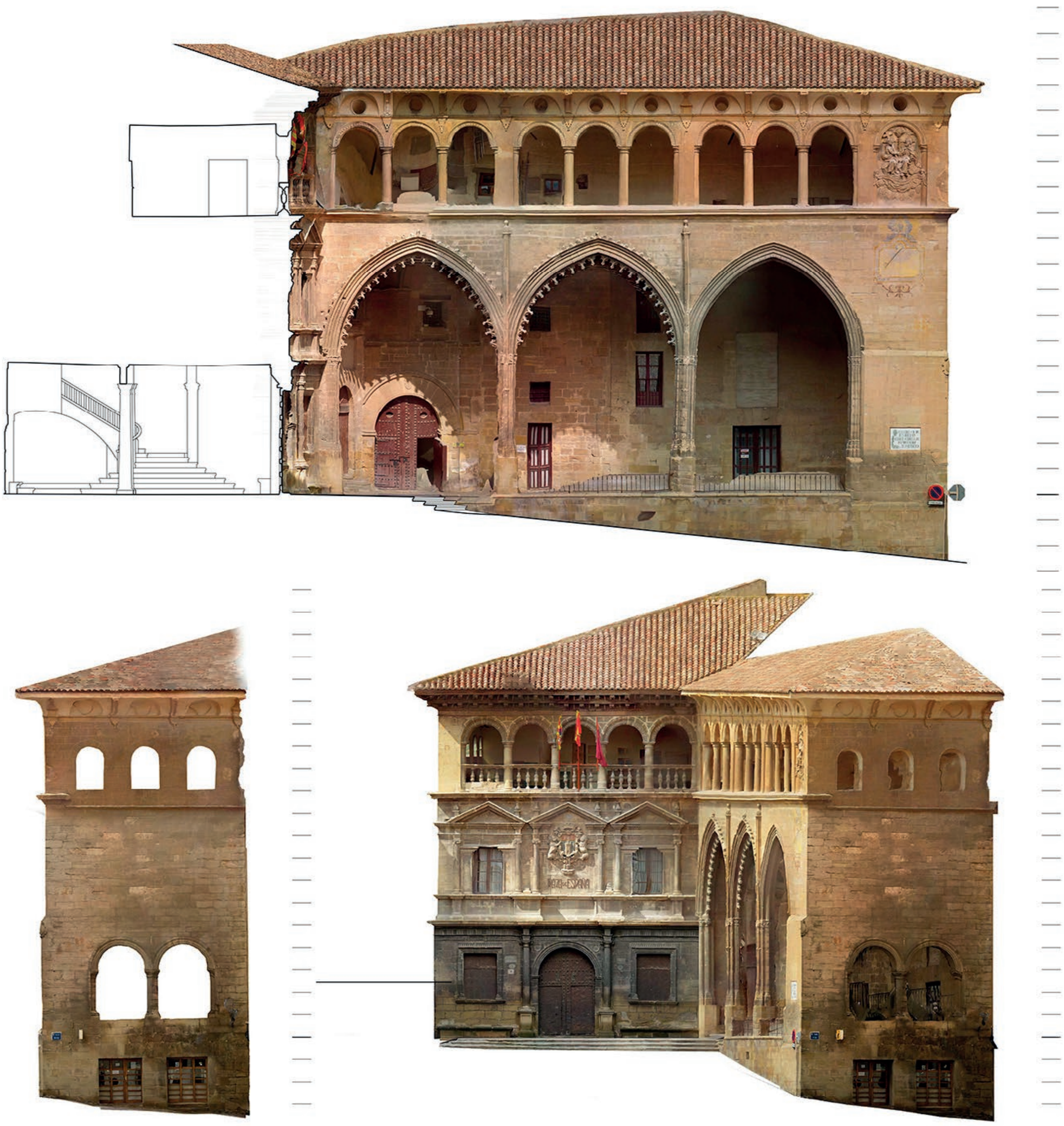

Figure 2 | Photogrammetric texture of the facades and gallery of the City Council and Lonja of Alcañiz.

out using the Photoscan software, allowing to obtain a point cloud which was completed with the information collected by the laser scanner. The combination of information from both was processed using Autodesk Recap software (Fig. 3).

The main results of the work and methodology used, is the development of a more complete and exhaustive documentation of the building. Compared with the information examined in the previous documentation phase, a non-existent documentation has been generated so far. The volumetric model obtained after the combination of photogrammetry and laser scanner allows to obtain all the geometric information of the building and its correct formal characterization, as well as to record its chromatic values. In this way, after carrying out a comparative analysis of the geometries obtained and the existing ones, important dimensional differences have been observed, obtaining great precision in the representation.

Figure 3 | Musée d'Orsay. *Source*: Second author's photo (2015).

3.3 Segmentation and classification

Once the 3D model has been obtained with the complete geometric information of the building, it is used as a basis on which to dump the data provided by the different technicians who participate in the restoration process. For this, BIM technology is used, which allows to store and organize a large amount of information in the same HBIM (Building Historic Information Modeling) model, and that it is capable of integrating data on a stratified support to be used in restoration, conservation or dissemination tasks, among others.

Before the integration of the 3D model in the BIM system, it is necessary to accomplish a series of actions that promote efficient information management, accessibility and interoperability between databases. By using segmentation and classification methods, a semantically enriched hierarchical relationship structure can be created.

To carry out the segmentation procedure, associated with regions of the model, data with similar properties are grouped. Once completed, the classification is carried out by means of its semantic labeling. The objective is to obtain a segmented model, rich in classes and properties, that allows to capture each degree of granularity required for the description of 3D models (Fig. 4). For subsequent enrichment with annotations, and thus, obtain a complete repository that allows queries and information management in an organized way (Quattrini et al., 2017).

To start the segmentation process, it is necessary to adapt the data set in an efficient way, to prepare the point cloud (Malinverni et al., 2019). Working with very large point clouds, sometimes require sub-sampling to be able to manipulate them. Segmentation is the process of grouping homogeneous data that have properties in common, based on some established criteria. There are several procedures to carry out this work: edges segmentation, regions segmentation, decomposition of the model in primitive forms or machine learning approaches, in which the model is not only segmented but is also classified semantically (Fig. 5).

The use of the segmentation methods described in the heritage field is difficult to apply, since the uniqueness of the buildings, made up of irregular elements, are difficult to standardize, parameterize and segment.

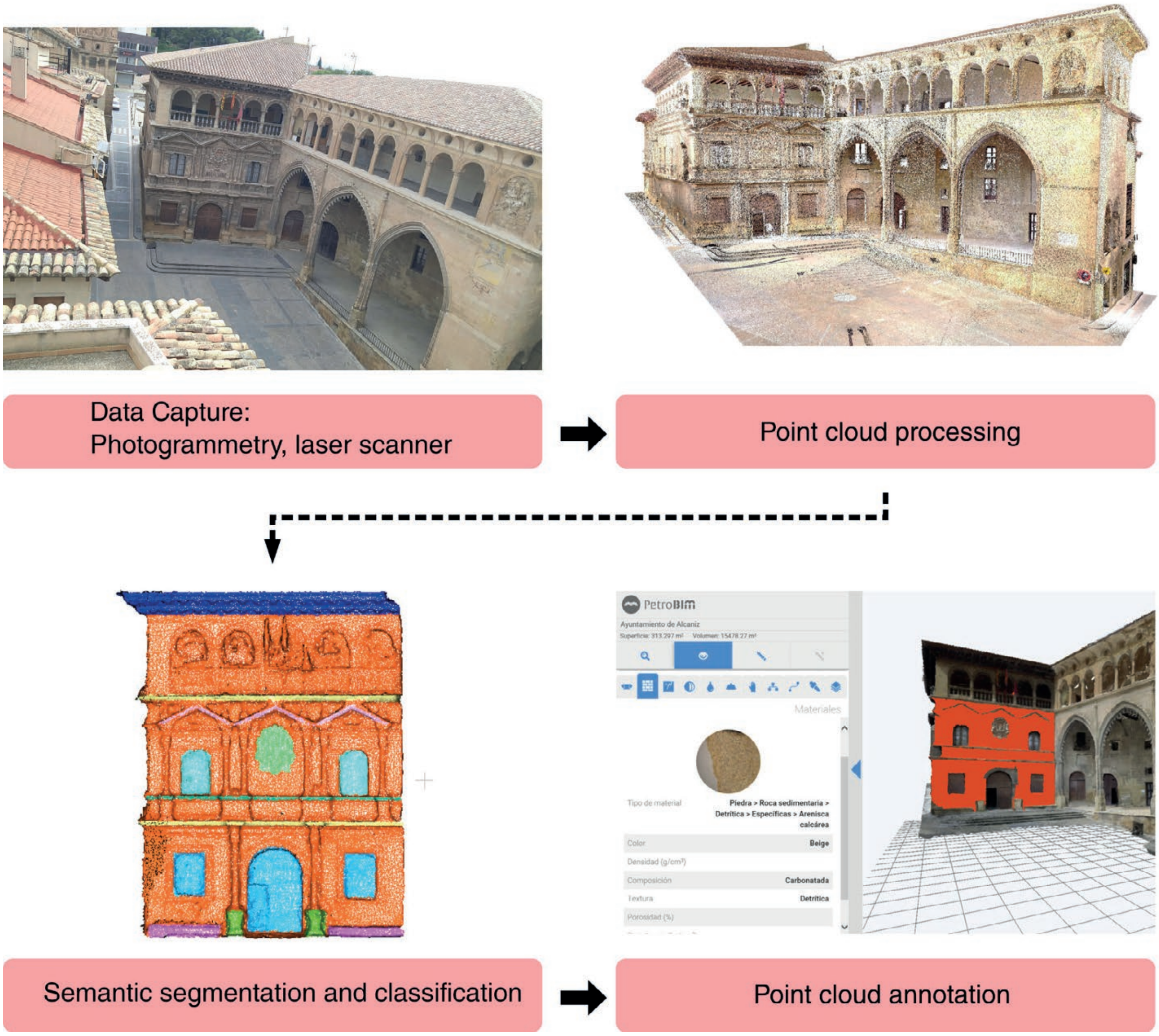

Figure 4 | General description of the proposed methodology.

This morphological peculiarity is solved thanks to the use of methods such as Machine Learning to accelerate segmentation and classification. It is possible to reduce classification times, favor the replication of the training in buildings with similar characteristics of the same architectural style or the visualization of the results on the 3D model. After the segmentation process, we proceed to the classification of the different parts into which the 3D model has been decomposed and organized under a semantic hierarchical structure. Classification consists of several steps: defining an ontology, assigning classes, calculating features, training models, and predicting.

Previously, an ontology adapted to the type of building to be represented must be developed. This ontology should be as specific as possible and must allow the detailed classification of all the levels of detail that are established for the representation of the entity. For this purpose, it is necessary to use a Knowledge Organization System, such as a glossary, taxonomy, thesaurus or lexical database as the CIDOC-CRM (CIDOC Conceptual Reference Model), developed by the CIDOC Documentation Standards Working Group, or others vocabularies, such as the Art and Architecture Thesaurus (AAT) produced by the Getty Institute. Once the ontology is defined, the class definition procedure begins by assigning a value for the

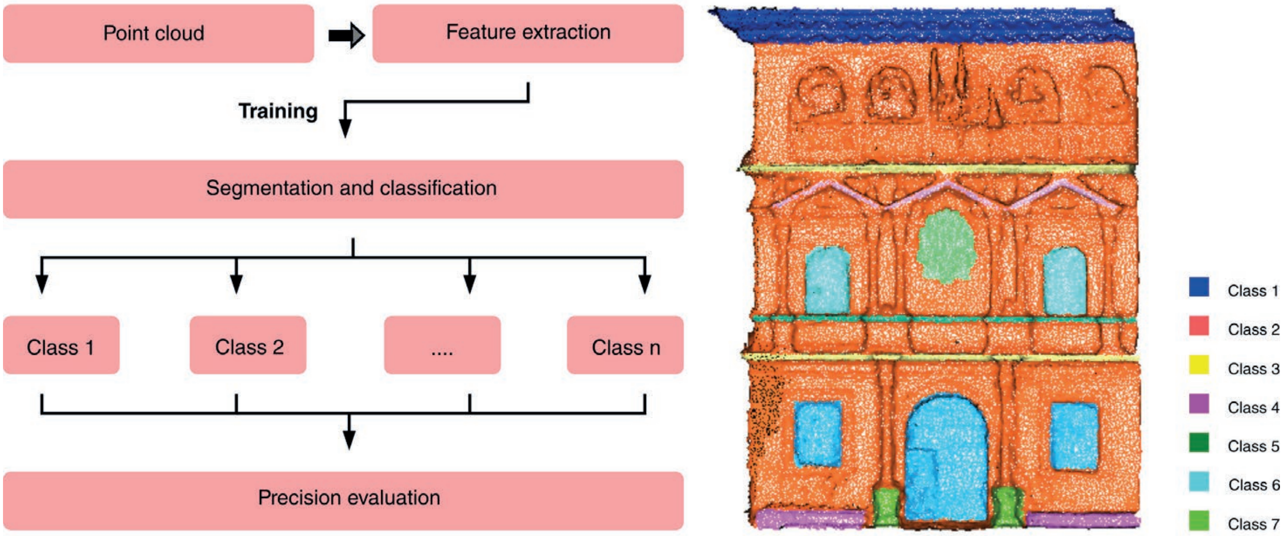

Figure 5 | . Workflow of the point cloud classification and segmentation process. Example of the façade of the Alcañiz City Council, in which the point cloud has been divided and classified into different architectural components.

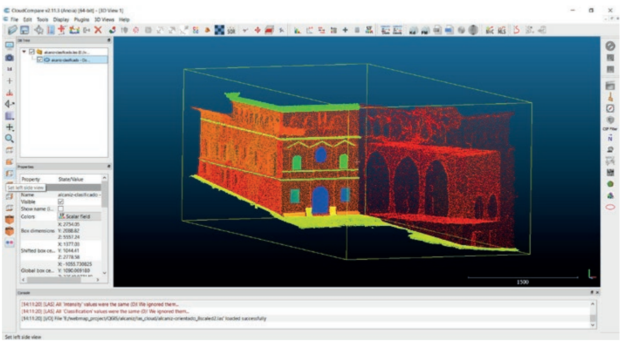

Figure 6 | . Set Point Cloud Segmentation in Cloud Compare.

label that classifies the previously segmented object. In Machine Learning methods, during the training phase, the algorithm learns from these decision nodes and connects them to a previously designed ontology. Through correction and repetition, learning and corrected classification are achieved.

In the specific case of the Alcañiz City Council and Lonja, the complete volumetric model was introduced in the open source Cloud Compare software (Fig. 6). This software allows the manual hierarchical orientation and segmentation of the model in the different components of the building, after analyzing the previous study of the construction phases and characteristics of the architectural style. Next, the model is exported to the PetroBIM software, in .fbx format, the only one allowed to incorporate 3D information to the platform.

The process of research and analysis of the architectural heritage generates a large amount of information and heterogeneous documentation. To organize information hierarchically, the annotation method is used to convert the syntactic framework into the knowledge structure. The complementary information is linked to the geometric model in order to allow its analysis. To carry out the procedure, it is necessary to perform a double action: the selection of a location-region on the surface of the 3D model and the definition of a relationship between the spatial element and the structured or unstructured data.

The documentation of the architectural heritage benefits from the use of the annotation process as a means for the introduction of complementary information to the 3D model of the building. Through the creation of thematic layers of information superimposed on the model, organization and non-duplication of data is promoted. At the same time, it facilitates the representation of different temporal states in the same model, the cross-analysis of information and a semantic structure based on the use of ontologies for managing information precisely.

3.4 Incorporation to HBIM

The BIM system allows the incorporation in multiple formats of information relative to the construction systems, historical evolution, physical characteristics or pathologies, creating a model that graphically represents the reality of the documented historical building. This database with visualization, documentation and management capabilities enables a complete view of the building from different points of view, which facilitates a complete knowledge of the building and favors collaboration between all the disciplines involved in heritage. At the same time, it favors interoperability with other databases and tools throughout the entire life cycle of the building.

In this work, the selected system has been PetroBIM, a tool developed for the management and consultation of information associated with a geometric model throughout the entire life cycle of the building. It consists of a viewer and a database that enables the exchange of information and real-time analysis of information related to historical heritage for the drafting of conservation and restoration projects (Armisén et al., 2016).

After the generation of the geometric model and application of the segmentation and classification processes, the next phase of work is to carry out the annotation procedure. For which, the Petrobim software was used as a database for managing the stored information and facilitating the organized and structured incorporation of the data associated with the model. After incorporating the 3D model into the program, the documentation from the archaeological report prior to the drafting of the restoration project was entered. The program consists of a database that incorporates different work modules with preloaded information regarding the characteristics necessary to draft conservation and restoration projects, such as materials, pathologies or historical phases, but with the possibility of introducing new concepts. An important feature to highlight is the temporal function, since information and data entry can be temporarily delimited individually by creating "campaigns" that allow comparative queries. Subsequently, the annotation procedure that began after segmentation was continued, by assigning the constructive characteristics to the different constructive elements into which the geometric model was segmented. The way of assigning the information is done through different specific modules for conservation and restoration work.

Through the modules, attributes related to construction materials were introduced, being able to choose from a predefined list in the database, describing properties such as composition, texture, color, porosity, resistance or humidity (Fig. 7). To then assign to the materials already defined, the pathologies shown in the archaeological report and defined in the database according to the terms collected by ICOMOS and COREMANS.

Furthermore, the "equipment and sensors tool" allows the information collected to be completed and assigned to the specific humidity and deformation modules, where the location of the sensors is located in the model Based on the information collected in the previous modules, the criteria and modes of intervention dictated by the results of the previous studies and the actions to be carried out according to each constructive element were defined (Fig. 8). Obtaining in this way, the cost of the intervention according to the measurement of the affected area, necessary to carry out a real control of the costs of execution of the restoration work. In addition, complementing the information related to the intervention works, the maintenance module allowed the introduction of the maintenance conditions defined in the restoration project and the assignment of periodicity and notification of the execution of the works to the assigned personnel.

After completing the data entry process to the platform, it was possible to examine the suitability of the system for the execution of analysis, through the simple or multiple search of information related between the different modules, simultaneously. In addition, the program incorporates tools to operate with the model, facilitating navigation and carrying out numerical and graphic queries, through the application of selective filters. The benefits of this work methodology favor that the information is available for consultation in real time, and at the same time, is accessible and centralized.

3.5. Results

The Petrobim platform has been conceived to manage the information and documentation generated by the different technicians involved in an intervention and conservation project. This management is arduous and difficult to carry out, therefore, a web platform has been designed aimed at unifying all the information generated. In this way, the information is accessible from multiple devices and from any location. Access to information from the different modules aimed at the conservation of buildings, facilitates the introduction of data and analysis.

However, some limitations related to the 3D model have been found. The software only supports the incorporation of a single file format, in addition to being oriented

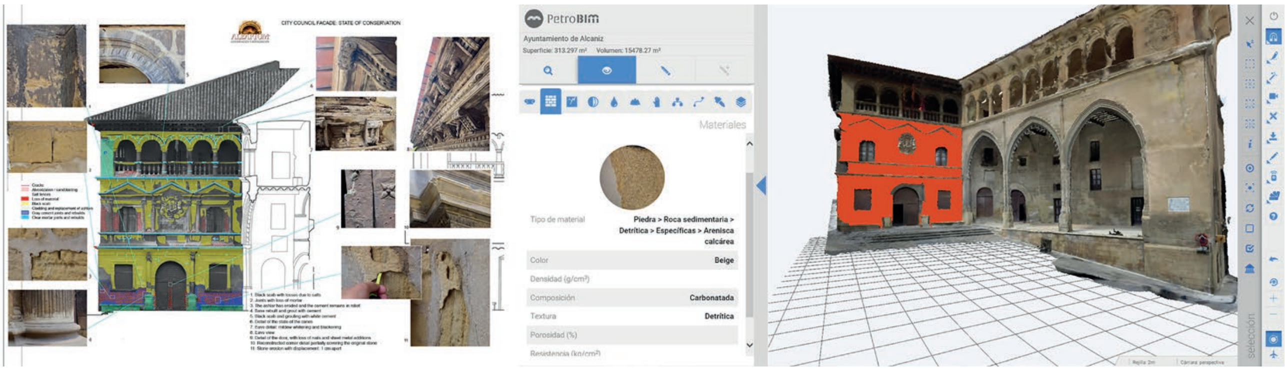

Figure 7 | Introduction of information from the archaeological report to the Petrobim platform.

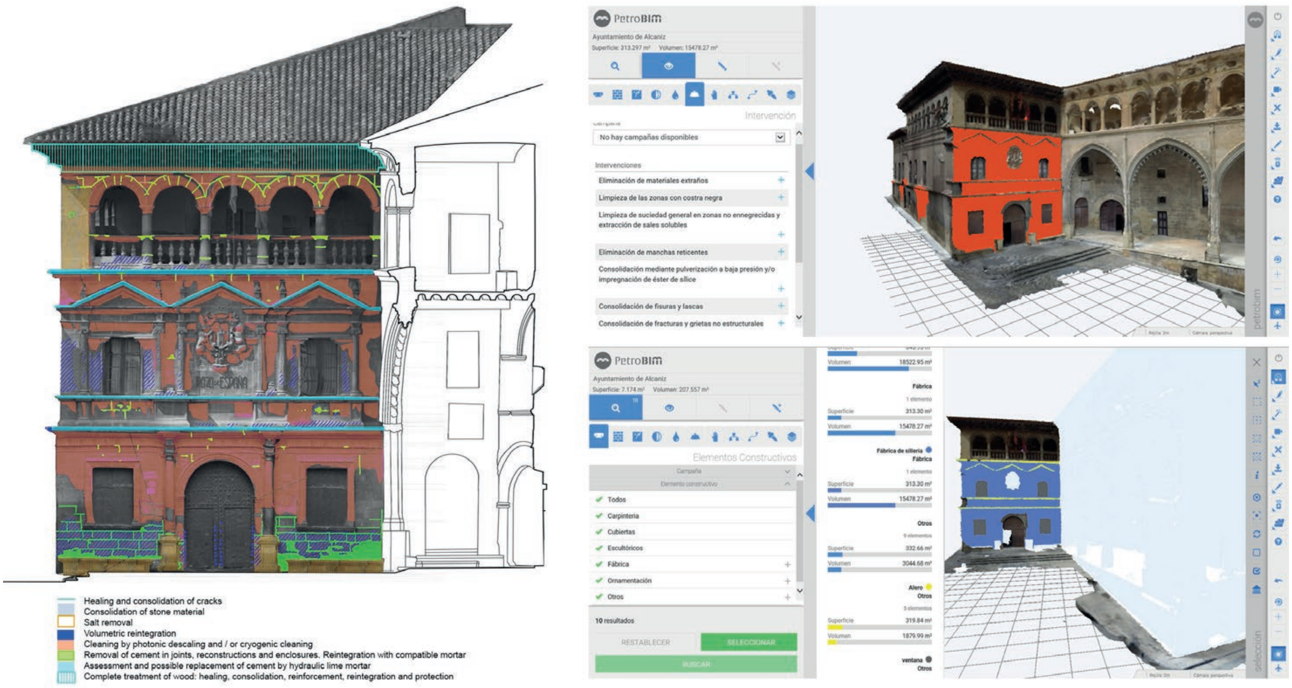

Figure 8 | Insertion of information regarding the state of conservation of the façade of the Alcañiz City Council in the 3D model by means of the point cloud annotation process, after having carried out a previous segmentation process.

to parametric objects. It has problems with the management of other types of models, such as meshes, having difficulty selecting the different segmented components of the model and assigning the construction elements. It should also be noted that the database of construction elements does not incorporate or allow incorporating a glossary such as those mentioned above. This option would favor interoperability with other information systems and users.

Compared to other commercial BIM software, the same strengths and weaknesses are found. But the limited editing capabilities of the 3D model stand out especially, as a basis on which to incorporate all kinds of information. Its differentiating element, compared to other BIM tools focused on new construction buildings, are the different management modules focused on heritage conservation, but it still has to develop certain key aspects in order to meet the interoperability and accessibility needs of information systems.

4. Conclusions

The documentation of the architectural heritage has been linked to the development of computer tools and acquisition techniques employed. The work methodology has been affected by this situation due to the evolution of the formats obtained as a result of the capture and the large amount of information generated. This heterogeneity of formats and information implies making changes in the management and storage methods of the information obtained, since it must be accessible. Data must be displayed quickly, accurately, without loss of information and compatible with other databases to promote interoperability and dissemination of information.

To manage large volumes of information, it is necessary to create a structure capable of displaying the data in an organized and accessible way for consultation. An Integral Information System, capable of managing knowledge, the integration of available materials, as well as the processing and analysis of these materials under a common support. The aim is to develop a graphic database to represent the information related to the architectural heritage through a 3D model. It requires an orderly representation of the stored information, due to the diversity of disciplines involved in the sector, with highly specialized fields and that affects the communication between the different technicians who intervene in the documentation processes.

The objective is to obtain a segmented model rich in classes, which allows its subsequent enrichment with annotations, as a means for the introduction of complementary information to the 3D model of the building. At the same time, it facilitates the representation of different temporal states in the same model, the cross-analysis of information and a semantic structure based on the use of ontologies for managing information accurately.

The Documentation Systems have evolved towards technologies developed with open source software, the use of standards, ontologies and the structuring of information and the 3D model itself under a semantic hierarchy. In this way, interoperability between databases is favored and long-term maintenance of applications is ensured, without large investments and ensuring accessibility for different types of users. The purpose is to support decision-making related to the model and simultaneously serve multiple purposes such as cataloging, protection, restoration, conservation, maintenance or dissemination, among others.

The architectural heritage is composed of complex and irregular elements, with shapes that make it difficult to parameterize objects and as a consequence, standardization and segmentation. Furthermore, BIM technology alone is limited with respect to attribute query functions as well as spatial ones. However, its integration with Geographic Information Systems, whose priority is the analysis and management of spatial information, solves mutual deficiencies It favors the creation of a complete repository in 3D, for the management of information related to heritage, in a spatial environment, capable of managing semantically enriched models. The semantic organization of the information facilitates interoperability between both databases, despite the fact that the integration is still not entirely satisfactory. This situation encourages the study of new methods that favor the flow of information. It is considered that BIM / GIS integration covers all specific needs that the documentation of the architectural heritage requires.

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