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RETRACED MEMORIES - VIRTUAL RECONSTRUCTION OF AN ARCHITECTURAL LANDMARK

MEMORIAS EVOCADAS - RECONSTRUCCIÓN VIRTUAL DE UN HITO ARQUITECTÓNICO

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Highlights:

- 3D virtual reconstruction is effective to visualize and bring back to life ruined architectural artefacts.
- Information about the artefacts original appearance was harvested through digital survey campaigns, archival documents, and comparisons with iconographic sources and coeval buildings.
- The 3D reconstruction follows ethical principles of transparency and combines photogrammetric meshes (partly relocated through a virtual anastylosis) and NURBS surfaces.

Abstract:

This paper addresses the challenge of digitally reconstructing ruined architectural sites and retracing their history, in order to virtually recompose their geometrical, stylistic and material integrity. To this end, the research team analyzed the ruins of the church of Santa Maria de Monasterio Albo, located in the ancient village of Misterbianco (Sicily) and destroyed (together with the entire hamlet) by the 1669 eruption of Mount Etna. In the last years, some excavation campaigns brought the church to the light, unveiling the remains of the main portal and six altars, which are one of the most remarkable examples of Mannerist art in eastern Sicily. This research aimed to three-dimensional (3D) reconstruct both the altars and the portal, ideally reviving their original 17th century configuration. This goal was achieved through an in-depth archival research (documents dating back to the years between 1300 and 1666 were consulted), an analysis of Classic and Renaissance treatises, and two integrated digital survey campaigns (laser scans and photogrammetry). The outcome is represented by the 3D models of the seven artefacts, which include surviving parts reconstructed as photogrammetric meshes, several fragments were placed in their likely early location through a virtual anastylosis, and NURBS (Non Uniform Rational Basis-Splines) surfaces (recreating the no longer existing elements). The latter were 3D modelled based on the treatises (which provided information on the correct proportioning) or in analogy with other coeval similar artefacts. Overall, the digital reconstruction was based on the ethical principles of transparency of the intervention, recognition of non-original additions and distinction between evidence and hypothesis, according to the London Charter and the Seville Principles. The experimentation provides a valid support for possible interventions in the real world and is the starting point to develop a digital archive of the site, which would make the different accuracy levels the reconstruction explicit.

Keywords: architectural ruins; documentation; 3D reconstruction; digital photogrammetry; architectural treatises; virtual anastylosis

Resumen:

Este artículo aborda el reto de reconstruir digitalmente las ruinas arquitectónicas y de recomponer su integridad geométrica, estilística y material. Para ello, los investigadores analizaron la iglesia de Santa María de Monasterio Albo, situada en el antiguo pueblo de Misterbianco (Sicilia) y destruida (junto con todo el burgo) por la erupción del Etna de 1669. En los últimos años, varias campañas de excavación han sacado a la luz la iglesia, revelando los restos del portal principal y los seis altares, que constituyen uno de los ejemplos más notables del arte manierista en el este de Sicilia. La investigación ha permitido reconstruir tridimensionalmente(3D) tanto los altares como el portal, reviviendo idealmente su configuración original del siglo XVII. Este objetivo se logró mediante una investigación de archivos (se consultaron documentos que se remontan a los años 1300-1666), un análisis de los tratados clásicos y renacentistas, así como dos campañas integradas de levantamiento digital (escaneado láser y fotogrametría). El resultado está representado por los modelos 3D de los siete artefactos, que incluyen partes supervivientes (reconstruidas como mesh fotogramétricas), varios fragmentos (colocados en su probable posición inicial mediante una anastilosis virtual) y superficies NURBS (*'Non Uniform Rational Basis-Splines'*, que recrean los elementos que ya no existen). Estos últimos fueron modelados en 3D, bien sobre la base de los tratados (que ofrecían información sobre las proporciones correctas), o bien por analogía con otros artefactos coetáneos similares. En general, la reconstrucción digital se basó en los principios éticos de transparencia de la intervención, reconocimiento de los añadidos no originales y distinción entre pruebas e hipótesis, según las Cartas de Londres y Sevilla. La experimentación ofrece un soporte válido para posibles intervenciones en el

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mundo real y es el punto de partida para desarrollar un archivo digital del sitio, capaz de explicitar los diferentes niveles de precisión de la reconstrucción.

Palabras clave: ruinas arquitectónicas; documentación; reconstrucción 3D; fotogrametría digital; tratados de arquitectura; anastilosis virtual

1. Introduction

This research aims to develop a methodology for the 3D digital reconstruction of “lost” historic architecture. This means the historical landmarks that currently survive in the form of ruins and are therefore no longer readable in their geometric and spatial integrity. This topic is part of a wider debate on the current digitization techniques of cultural heritage and the virtual anastylosis issues. The knowledge of the geometric rules underlying the construction of a building is in fact the most effective means not only to abstract ideal proportions and construction practices of intact artefacts (Rabasa et al., 2012; Aliberti & Alonso-Rodríguez, 2018; Piemonte, Caroti, Martinez-Espejo Zaragoza, Fantini, & Cipriani, 2018; Spallone, 2019), but also to imagine artefacts that never existed (Apollonio, Fallavollita, Giovannini, Foschi, & Corso, 2017; Garagnani, Cancilla, & Masina, 2019; Frommel, Apollonio, Gaiani, & Bertacchi, 2020) or no longer exist, or that are ruined (Cipriani, Garcia-León, & Fantini, 2019). Understanding empirical rules, modularity and proportions allow to complete and visualize ideally what is no longer possible to observe. Specifically, the approach described in this essay has been applied to one of the most significant examples of late Renaissance architecture in eastern Sicily, the decorative apparatus of the church of Santa Maria de Monasterio Albo in the ancient village of Misterbianco (Catania, Sicily), covered and partially destroyed by the eruption of Mount Etna in 1669. The imposing ruins of the building, brought to light in the last 20 years, testify to a historical period still little documented in eastern Sicily, due to the catastrophic events that devastated this side of the island during the 17th century. The study focuses on the six altars and the main portal of the church, which have been 3D reconstructed as they appeared in 1669, just before their destruction caused by the eruption. On the whole, the paper is structured as follows: Section 2 discusses the state of the art and the related works; Section 3 is an overview of the case study and its history; Section 4 summarizes the steps of the adopted methodology, from the cognitive phase to 3D modelling; Section 5 focuses on the cognitive phase; Section 6 describes in detail the 3D reconstruction of the altars and the portal; Section 7 provides a discussion about the outcomes of the research; and Section 8 is dedicated to the conclusion and future research.

2. Related works

One of the challenges in digital reconstructing complex and in some ways, enigmatic architectural masterpieces is related to understanding the building in all its facets, from the current state to the analogies with similar artefacts. In this regard, the first difficulty lies in the proper use of the most advanced digital surveying (laser scanning and photogrammetry) and 3D modelling techniques, increasingly effective in producing detailed virtual reconstructions of cultural heritage. These digital replicas represent an extremely effective tool to disseminate, understand and interpret the architectural cultural heritage, both in the case of intact artefacts and in the case of architectural/archaeological ruins (Forte, 2007; Forte, 2014; De Vos & De Rijk, 2019; Wong & Santana Quintero, 2019). Undoubtedly, the high realism of digital reconstructions raises several ethical issues related to the authenticity of replicas, and implies the need to integrate documentary sources and interpret them as stated in the London Charter the computer-based visualisation of cultural heritage (Hermon & Kalisperis, 2011; Cignoni & Scopigno, 2008; Brusaporci & Trizio, 2013; Buglio, Lardinois, & De Luca, 2015; Frommel & Schlimme, 2020). For this reason, it is essential to encourage innovative procedures for the visualization and validation of the (indeed mainly subjective) reconstructive process of a monument in a no longer existing configuration (Aiello & Bolognesi, 2020; Giovannini, 2020). These new approaches make explicit the link between the reconstructed elements and the information underlying the reconstruction (thus showing the gap between the interpretation and the original data), as well as the different levels of plausibility and uncertainty of the 3D modelled parts (Apollonio & Giovannini, 2015; Grellert, Apollonio, Martens, & Nubbaum, 2018; Demetrescu & Fanini, 2017). Virtual replicas are also starting to show their extraordinary potential in the field of restoration. Thanks to 3D reconstructions, it is in fact possible to study and hypothesize strategies that would be difficult to carry out due to conservative instances (Stampouloglou et al., 2020; Guidi, Russo, & Angheleddu, 2014; Lerones, Llamas, Gómez-García-Bermejo, Zalama, & Castillo Oli, 2014). In this regard, the technologies just mentioned have led to the concept of virtual anastylosis, which is an evolution of the traditional definition of anastylosis reported in the Charter of Venice (Charter of Venice, 1964). According to this document, anastylosis is a procedure through which some existing but dismembered portions of a monument are reassembled and relocated in their original position, and possibly integrated with supporting elements that must be made of new materials, easily distinguishable from the original pieces (so as to make the intervention immediately recognizable). Similarly, the so-called virtual anastylosis can be described, according to the Seville Principles, as a procedure that involves "restructuring existing but dismembered parts into a virtual model" (Seville Principles, 2011). The concept of virtual anastylosis is closely related to virtual restoration, which "involves using a virtual model to reorder available material remains in order to visually recreate something that existed in the past" (Seville Principles, 2011). In recent years, several academic studies have successfully focused on virtual anastylosis projects of ancient ruined monuments, in order to bring back to life the original appearance of the analyzed artefacts. It is the case of the columns belonging to the Circus Maximus in Rome (Canciani et al., 2013); the Roman Theatre of *Fanum Fortunae* (Quattrini, Pierdicca, Frontoni, & Barcaglioni, 2016), that was digitally reconstructed starting from historical and metric sources and highlighting the choices in the modelling phase; the scattered friezes belonging to the Teatro Marittimo of Villa Adriana, (Adembri, Cipriani, & Bertacchi, 2018). In this context, (Giovannini, 2020) proposes accurate cataloguing and relocation of the isolated fragments belonging to the

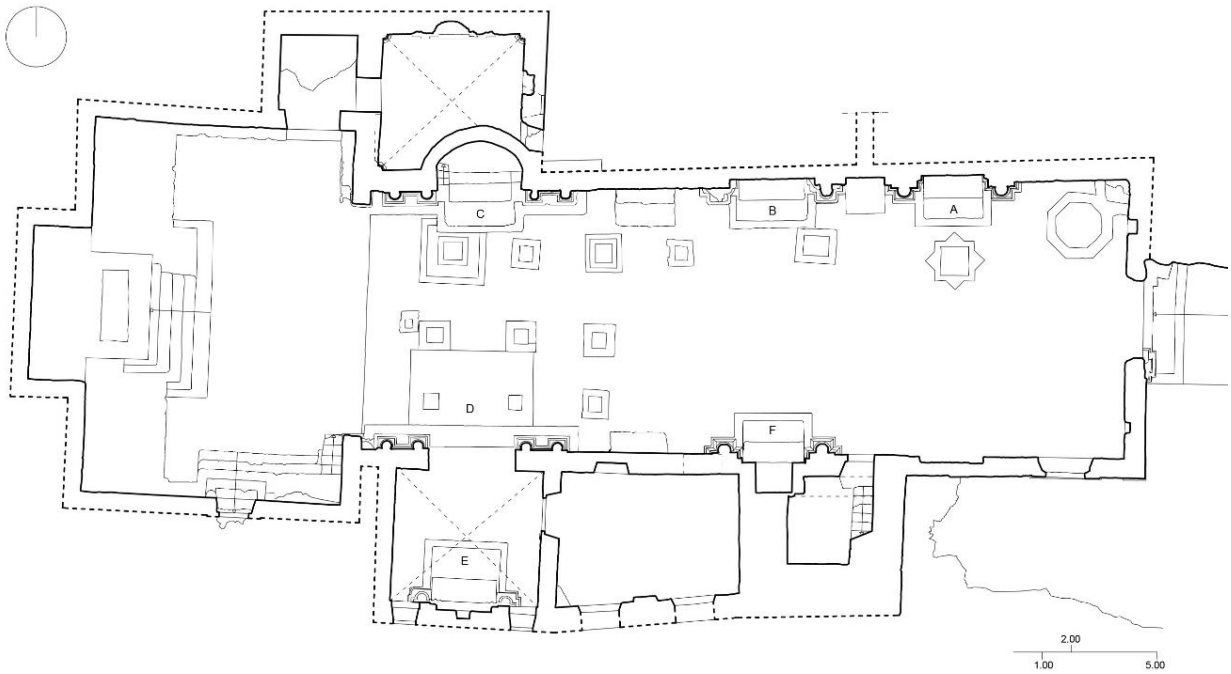

Figure 1: Plan of the archaeological site of Santa Maria de Monasterio Albo: A) presumed altar of Purgatorio; B) presumed altar of Madonna del Carmelo; C) altar of Madonna delle Grazie; D) monumental entrance to the chapel of the Crocifisso; E) altar of Crocifisso; F) presumed altar of Sant'Erasmo.

ciborium and the pergola of the Monte Sorbo church, and develops innovative ways of enjoying the research output through online platforms. The digital reconstruction of the decorative apparatus of Santa Maria de Monasterio Albo has been inspired by the principles set out in the considerations mentioned above, and can be in turn configured as a virtual restoration/anastylosis. The 3D modelling followed the cognitive phase and was based on the principles of transparency and ethical reconstruction (in accordance with the London and Seville Charters), in order to ensure a clear distinction between original surviving parts and fully reconstructed parts (no longer existing in reality).

3. An overview of the case study

The ruins of the church (Figs. 1, 2) represent one of the few visible pieces of evidence of the existence of the ancient village of Misterbianco, almost entirely buried by lava in the night between 29 and 30 March 1669 (Mancino, 1669), in the early stages of the most destructive eruption of Mount Etna in recent centuries. The lava flow did not totally cover the church's bell tower, which remained probably intact until the earthquake of 1693. The ruins of the tower gave the name to the area where the church stood, called "Campanarazzu". After the catastrophic event, the inhabitants of Misterbianco refounded the town 5 km southwest of the old site. They nevertheless did not lose the memory of their origins, evoked by the bell tower's remains (Fig. 2a). Over the years, many speleological investigations were conducted in the ancient lava flow, with the aim of finding further surviving traces of the church destroyed by the eruption. In 2002, the Sicily Region has authorized the first real excavation campaigns in the site, which have allowed to bring to light, consolidate and make accessible the remains of the entire building between 2003 and 2016. The artistic and architectural heritage recovered after the excavation and restoration campaigns is particularly significant, not only because of its degree of conservation, but also because it represents a rare synthesis of architectural styles (from late Gothic to Renaissance-Mannerist) whose traces have almost disappeared in Eastern Sicily, due to the 1669 eruption and the catastrophic earthquake of 1693.

(a)

(b)

Figure 2: Ruins of Santa Maria de Monasterio Albo nowadays: a) Exterior; and b) Interior of the nave.

In its current configuration, the church appears as a single-nave building with a large chancel and various collateral environments: on the south side, the bell tower, the sacristy and the chapel of the Crocifisso; on the north side, the Gothic chapel (the oldest existing room) and other rooms still inaccessible. The nave (almost 40 m long from the entrance to the apse) is decorated with 4 imposing limestone Mannerist altars (and, in addition, the monumental entrance to the chapel of the Crocifisso), largely preserved or partially reconstructed by anastylosis during the restoration works.

These precious artefacts seem to be inspired by the classical triumphal arches, with a central fornix flanked by one or two pairs of Corinthian semi-columns. A further altar, well preserved in the lower half, is located inside the chapel of the Crocifisso. In addition to the altar ruins, the site houses a number of fragments of the decorative apparatus ejected by the lava flow and found during the excavation campaigns. These fragments have never been analysed in-depth and are the subject of the present study.

In the next paragraphs, we will refer to the plan of the temple in Fig. 1, which shows the location of the altars.

4. Methodology

The developed methodology has taken into account a complex cognitive phase to gather valuable information on the original appearance of the building through digital survey campaigns, ancient archival documents, comparisons with iconographic sources and coeval buildings. Where these sources could not provide sufficient information, the reconstruction was integrated by referring to classic-Renaissance treatises, which allowed to understand the grammatical rules, the structure and the architectural language hidden in the surviving columns, pedestals, moldings (Morolli, Cantini, & Ente Cassa di Risparmio di Firenze, 2013; Bianconi, Filuppucci, & Magi Meconi, 2019). Thus, the methodology is essentially structured as follows:

- Cognitive phase, which consists of the harvesting of documentation (archive, treatises, samples of coeval altars in the same area) and data (3D acquisition of the church and the fragments) to support the choices to be made during the reconstruction process and/or the virtual reassembly of the fragments, that is:
  - Archival documents dating back to the period 1300-1666;
  - Classic and Renaissance treatises, useful to understand the geometric rules underlying the proportions of the architectural orders;
  - Comparative study of coeval altars and portals (dating back to the 16-17th century).
  - Two integrated digital survey campaigns (laser scans + SFM photogrammetry) aimed at acquiring the actual configuration of the ruins.
- Digital reconstruction of the altars and the portal in their 17th century configuration by means of:
  - Retopologized photogrammetric meshes;
  - Virtual anastylosis of the isolated decorative fragments;
  - 3D NURBS modelling of parts that no longer exist.

The following image summarizes the fundamental steps of the workflow (Fig. 3).

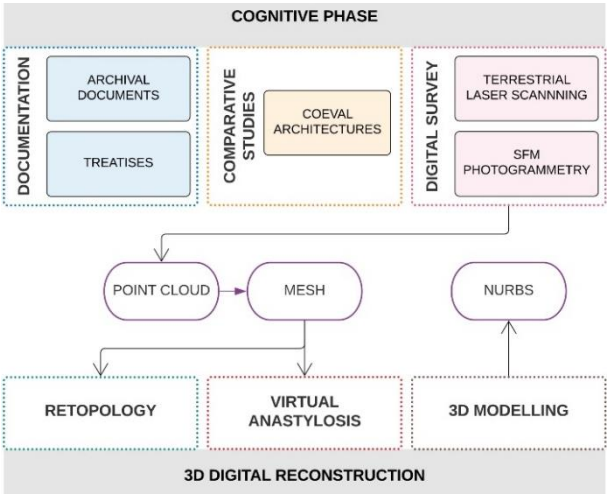

Figure 3: Overview of the adopted methodology.

5. Knowledge and documentation of the archaeological site

The digital reconstruction of Santa Maria's decorative apparatus was preceded by an in-depth cognitive phase, which allowed us to acquire an overview of the current state and to elaborate the first hypotheses on what the altars and the portal looked like before the eruption. The first step consisted of consulting ancient archival documents dating back to the years between 1300 and 1666.

These documents, kept in the Historical Diocesan Archive and in the State Archive of Catania, concern pastoral visitations, *jugalia* (i.e. lists of precious objects owned by the church) or exchanges of letters. Despite the many gaps, the archival documents have provided valuable information about the name and the probable period of construction of the altars (mid-17th century).

At the same time, the research team conducted a comparative study in order to investigate similarities and differences between the case study and the decorative apparatus belonging to other 16th and 17th century Sicilian churches, characterized by the proliferation of refined stone altars, typical of the Counter-Reformation period. In this regard, the study focused on the church of San Pietro in Piazza Armerina, the churches of Sant'Antonino and Santa Maria la Vetere in Militello in Val di Catania, and the Duomo of Condrò.

In this regard, the analogies with the church of San Pietro (Fig. 4) are particularly useful for understanding the internal layout of Santa Maria de Monasterio Albo. The two buildings share in fact a similar plan, as well as a succession of decorative stone artefacts in the form of triumphal arches (which, in the case of San Pietro, have the role of monumental entrances to the six chapels).

Figure 4: Church of San Pietro, Piazza Armerina. Interior.

The documentation acquired during the cognitive phase includes the data obtained from a first digital survey campaign, conducted in 2016 by the Luigi Andreozzi Laboratory of Architectural Photogrammetry and Survey (University of Catania), in the context of a first study and documentation of the archaeological site (Santagati, Lo Turco, & Garozzo, 2018). On this occasion, 17 scans were recorded by means of using a Leica HDS 3000 time-of-flight laser scanner. The outcome was an accurate point cloud of the entire building (107.4 million points, with an alignment error of 3 mm in the Cyclone v. 9.1 software) (Fig. 5). This numerical model has been the main reference for all the following measurements and reconstructive assumptions.

Finally, a photogrammetric digital survey campaign was carried out between 2019 and 2020. In this case, in order to ensure the acquisition of a large number of objects, 3 professional cameras were used: a Canon EOS 70D, a Canon EOS 1200D and a Nikon D5300, set in manual shooting mode to produce images with better exposure, definition and accuracy of chromatic information. The collected photographic dataset was imported and aligned within the Agisoft Metashape v. 1.5 photogrammetric software, which allowed to obtain the textured photogrammetric meshes of the 6 altars, the portal and 28 isolated fragments of the decorative apparatus, temporarily stored in a depository inside the archaeological site, since their original location is not yet known. The polygonal models of the altars have been correctly scaled and georeferenced with respect to the coordinates of the laser scanner point cloud. The models of the 28 fragments were in turn scaled (based on targets used during the survey) and catalogued in a series of datasheets that summarize all the characteristics and hypotheses on the presumed original location (Fig. 6). Where the exact position of the fragments was unknown, the researchers circumscribed as much as possible the area of possible location, excluding all the parts of the altar where the fragment certainly could not be placed.

Figure 5: Laser scanner point cloud of the nave.

6. Reconstructing from fragments. The 3D modelling project

The 3D digital reconstruction of the altars and the portal was conceived as a real restoration, and as such, it was characterized by the ethical principles of transparency of the intervention (Brusaporci, 2017), recognition of non-original additions and distinction between evidence and hypothesis. (London Charter, 2008; Seville Principles, 2011). The reconstruction was carried out using as reference the seven photogrammetric meshes of the ruins. These polygonal models are particularly heavy and difficult to manage within the 3D modelling software. To solve this problem, the meshes have been imported into the ZBrush 2019 software, where they were optimized through a process called retopology (Palestini & Basso, 2019). This operation made it possible to lighten the seven models, reducing the number of polygonal faces and modifying their triangular geometry in a quadrangular one, without altering the apparent level of detail. The optimized models were then imported in OBJ format into the Rhinoceros v. 6. This software has been chosen to create complex 3D elements in the form of NURBS mathematical surfaces with a high accuracy (which would be more difficult to achieve within different modelling software). In general, the digital reconstruction followed three different criteria:

- The ruins of the altars and the portal, survived in their original location, were re-proposed in the form of photogrammetric meshes, since they are the most effective means to faithfully reproduce all the refined details of the sculptures and the bas-reliefs, as well as the patinas, deformations and marks due to flow of time.
- 15 of the 28 isolated decorative fragments have been located into the 3D reconstruction as photogrammetric meshes and have been reassembled in their original probable location by means of virtual anastylosis. In accordance with the considerations of (Alby et al., 2017), different types of anastylosis were distinguished, depending on the relative location of the fragments involved (i.e. the physical distance between the pieces), which determines different modes of assembly. Specifically, the researchers identified contiguous fragments separated by a sharp crack; fragments that are contiguous but whose contact surface has been eroded; and, finally, fragments that belong to the same element (e.g. arch, semi-column, pilaster, etc.) but are not contiguous.
- The elements no longer existing or no longer recognizable (in particular entablatures, arches and some semi-columns) have been modelled in Rhinoceros on the basis of Classical and Renaissance treatises (which provided information on the correct proportioning of the architectural orders) or in analogy with other coeval altars and portals, which are supposed to be similar to the ones to be reconstructed.

Reintegration has been reduced to a minimum, without erasing the traces left by time on the surviving parts (furrows, cracks, deformations, small gaps, material-chromatic facies) and clearly visible in the textured photogrammetric meshes.

Figure 6: Datasheet of the seven fragments belonging to the altar of Madonna del Carmelo. On the right, presumed original location. The pink color indicates the areas of possible location of the fragment; the red color indicates the location chosen for the virtual anastylosis.

6.1. Altar of Santa Maria delle Grazie

The altar presents the characters of the classical Corinthian order (pedestal, column, entablature), yet contaminated by original elements, according to expressive freedom typical of the Mannerist style. It is the case of the pilaster strips decorated with spirals, the two niches (originally surmounted by ovals), the four dados placed between the pedestal and the base of each semi-column (Fig. 7a). By analyzing the proportions of the altar, it has been possible to rediscover some plausible modular geometric rules that connect the single parts to each other. This operation has been facilitated by the two intact semi-columns, from which the *modulus*, i.e. the module, has been obtained. As is customary in the theory of architectural orders (according to treatises), the module coincides with the diameter of the semi-column shaft at the bottom, called imoscapo. This quantity is the reference used to establish the dimension of all the other components. Comparing the module to the surviving portions of the altar, some interesting data emerged. First, the proportioning of the parts seems to remind the rules codified by Vignola for the Corinthian order (Vignola, 1562). Specifically, the height of the entire semi-column (from the base to the capital) is about 10 diameters (or 20 radii, i.e. 20 moduli, according to the nomenclature used in Vignola's treatise), while the pedestal is about 3.5 diameters (7 Vignola's radii), equal to 1/3 of the height of the entire semi-column. The base of the semi-columns (made of three tori alternating with two scotias) is in turn consistent with Vignola's Corinthian order; the bases are in fact the variants of what other treatises define the ionic base, considered by Vignola as the most suitable for the Corinthian order. It is therefore evident that the masons who built the altar (although probably not directly aware of Vignola's theories) followed a known and consolidated constructive practice, codified by Vignola in *La regola delli cinque ordini d'Architettura*. Since it seems that some geometric rules similar to Vignola's ones have been followed, it is likely that the entablature (whose hypothetical surviving fragments are no longer recognizable) was not an exception; it is, therefore, plausible that it was 1/4 of the semi-column height. The no longer existing parts were then 3D modelled using these measurements as a reference. The different types of elements were modelled according to different criteria: the two left semi-columns were simply reconstructed in analogy with the two survivor ones; the left pilaster strip, niche and oval, all destroyed by a landslide in 2009, were reconstructed using as a reference the photographic documentation portraying them before the collapse (Fig. 7b). The right pilaster strip, niche and oval were instead reconstructed by symmetry with their counterparts on the left. The entablature was modelled exclusively following the proportions and graphic representations by Vignola. The central round arch was completed by setting the springer plane at 2/3 of its total height (location and height of the arch are easily deduced from the remains of the impost blocks and are somehow constrained, once the other parts of the arch are known). The 3D reconstruction was finally completed by relocating, through the virtual anastylosis, five of the 28 fragments surveyed in 2020 (Fig. 9). The correct position of these elements was inferred from the images showing the altar before the partial collapse in 2009 (Fig. 7b) as well as from the evident similarities between isolated fragments and parts of the altar that remained in their original placement.

(a)

(b)

Figure 7: Altar of Santa Maria delle Grazie: a) Current state; b) The altar before the 2009 landslide. Photos by G. Sciacca.

6.2. Entrance to the chapel of the Crocifisso

The pedestals, the bases, most of the shafts of the four semi-columns, the springer of the arch and the two side niches (containing the stucco remains of two statues) of the entrance are almost intact (Fig. 8). The entrance looks similar to the altar of Santa Maria delle Grazie. There are only small differences in size; compared to this altar, in fact, the arch is slightly wider (3.06 m), the two niches higher (0.50 x 1.66 m) and the two ovals placed in a higher position than their counterparts. The diameters of the semi-columns at the imoscapo are slightly smaller, as well as, consequently, the heights of pedestals and semi-columns. The modular scheme is nevertheless identical to the one of the altar of Santa Maria delle Grazie, so the monumental entrance has been reconstructed (Fig. 10) using the same module and the same constitutive parts (moldings, frames, floral decorations).

Figure 8: Entrance to the chapel of the Crocifisso in its current state. Photo by G. Sciacca.

Figure 9: 3D model of the altar of Santa Maria delle Grazie. In white, NURBS. In the original colours, photogrammetric mesh of the surviving parts. In red, virtual anastylosis. Below, note the deformation of the steps due to the collapse of 1669.

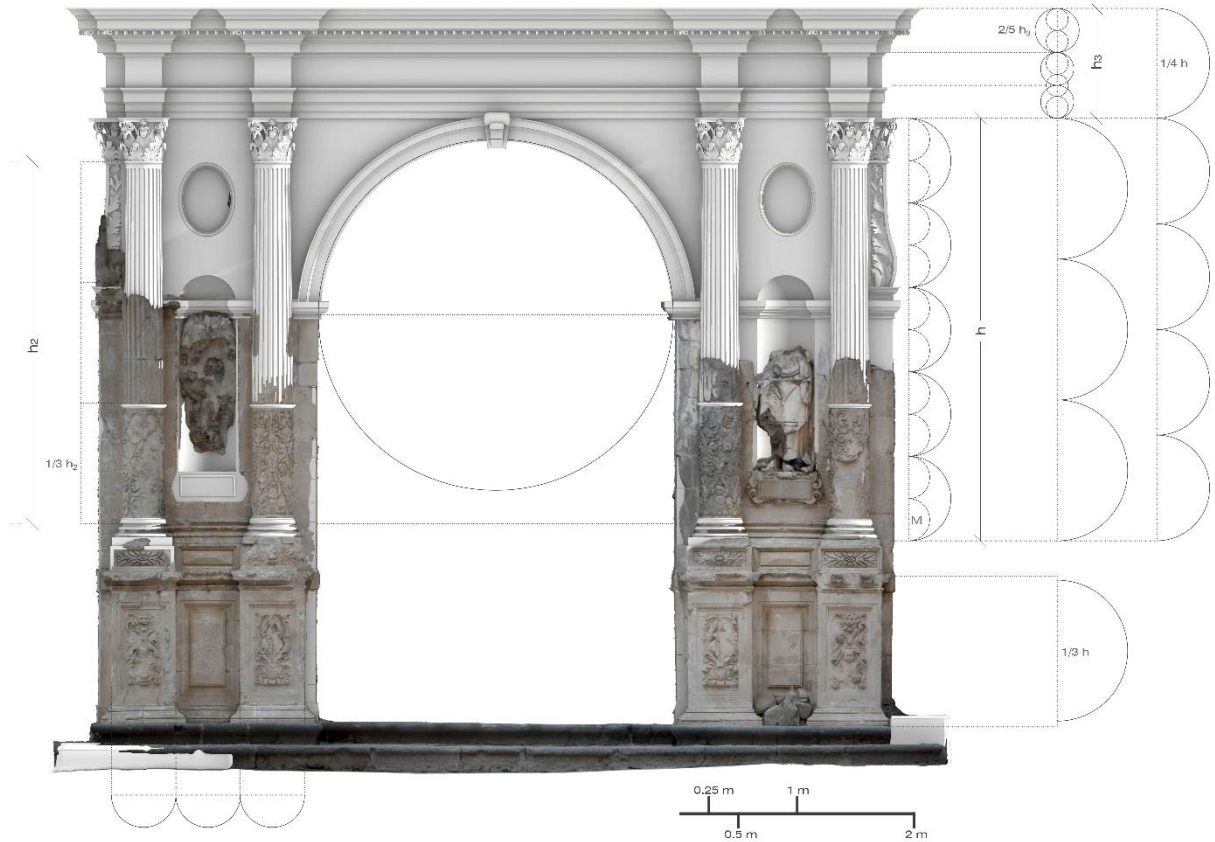

Figure 10: 3D model of the entrance to the chapel of Crocifisso. In white, NURBS. In the original colours, photogrammetric mesh of the surviving parts.

(a) (b)

Figure 11: a) 3D model of the altar of Sant'Erasmo; b) 3D model of the altar of the Purgatorio. In white, NURBS.n the original colours, photogrammetric mesh of the surviving parts.

6.3. Altar of Sant'Erasmo

The presumed altar of Sant'Erasmo is undoubtedly the most precious decorative artefact in the church, since it is almost intact, except for a few gaps and some chemical-chromatic alterations (presumably caused by the high temperatures reached during the eruption). This altar, together with the twin altar attributed to the Souls of Purgatory, is a Corinthian triumphal arch with proportions similar to the ones of the Vitruvian Corinthian order (semi-column as tall as 8 diameters at the imoscapo) (Vitruvio, 1790). According to the ethical principles already mentioned, the few missing parts of the altar have not been reconstructed; the photogrammetric mesh is in fact enough to give a complete overview (better than any possible NURBS 3D model) of the original altar (Fig. 11a).

6.4. Altar of Purgatorio

As regards the presumed altar of Purgatorio (almost entirely reassembled during the 2015 restoration), the researchers followed a similar strategy to the one described in the previous paragraph; the photogrammetric mesh of the altar was therefore completed with limited additions in the central part of the entablature and the round arch (the only elements modelled as NURBS) (Fig. 11b).

6.5. Altar of Madonna del Carmelo

It is one of the least preserved altars. The only surviving parts are the altar stone, some crumbled portions of the left pedestal, as well as the right pedestal and semi-column (reassembled during the excavations and devoid of capital). The remaining fragments are however sufficient to understand that this altar is a hybrid structure, halfway between the two larger artefacts (altar of Santa Maria delle Grazie and entrance to the chapel of the Crocifisso) and the two smaller ones (Sant'Erasmo and Purgatorio). The artefact shares with the larger altars some parts, including the dado inserted between the base of the semi-column and pedestal. The decorative apparatus seems, however, more similar to the minor altars, which is also confirmed by seven of the isolated fragments (belonging to the arch, the pilaster strips and the entablature) that were reassembled in the altar's 3D model, in their likely correct position. The latter was deduced from the stylistic similarities and continuity between the fragments and the remains still in their original place (after excluding a possible relocation in other altars). In general, the most significant decorative elements are the remains of the entablature, the floral decorations of the arch, the phytomorphic bas-reliefs of the pilaster strips, the vegetal sculptures of the pedestals and of the semi-columns, with their characteristic griffon heads. These elements are all identical to the ones of the two minor altars (Fig. 12).

Figure 12: Base and shaft of the altar of Purgatorio (decorations common to the altars of Sant'Erasmo and Carmelo).

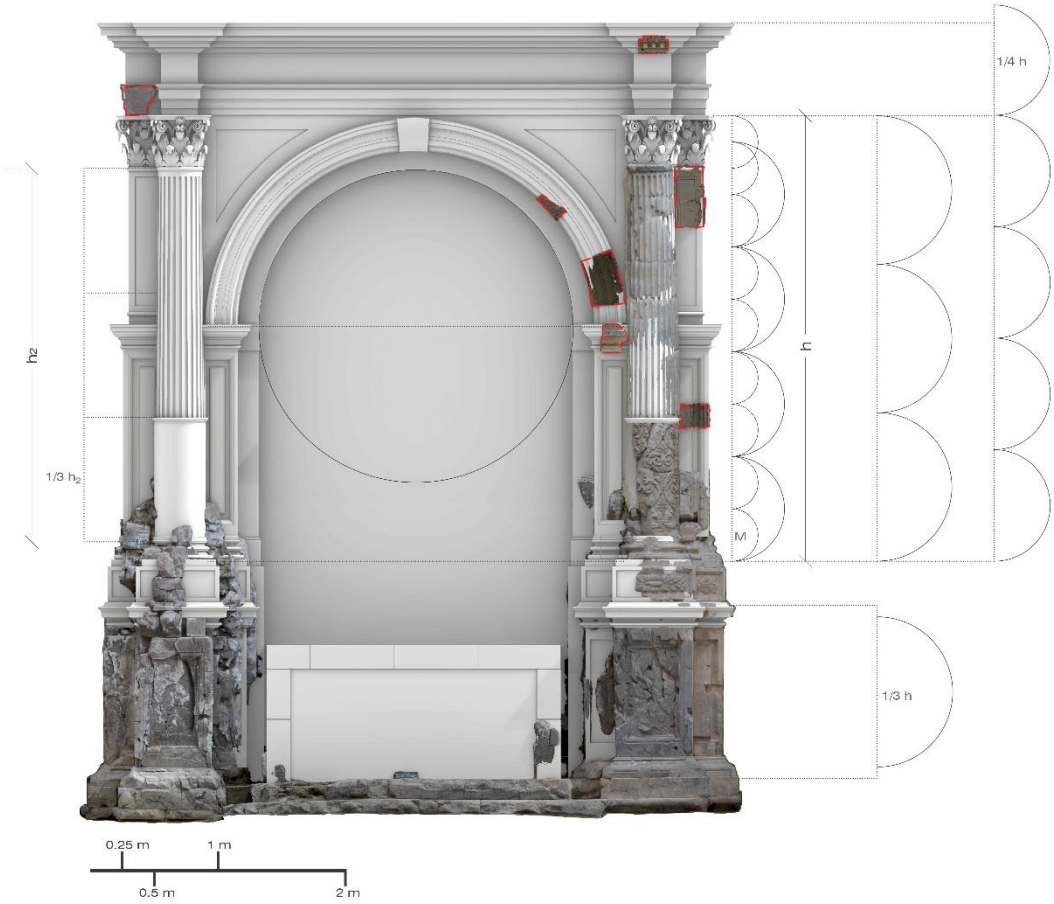

Figure 13: 3D model of the altar of Madonna del Carmelo. In white, NURBS. In the original colours, photogrammetric mesh of the surviving parts. In red, virtual anastylosis.

An analogous consideration can be made also for the modular scheme; unlike the first altar and the entrance to the chapel of the Crocifisso, the semi-column of the altar of Madonna del Carmelo has a height equal to 8.5 diameters, more similar, therefore, to the proportions of the Corinthian Vitruvian column. Moreover, in analogy with the two minor altars, the pedestal has a height of about 20 cm higher than 1/3 of the height of the semi-column.

Considering these peculiar characteristics, the missing parts of the altar have been reconstructed using as a reference the modulus and the proportions of the altars of Purgatorio and Sant'Erasmo.

The reconstructed artefact (Fig. 13) appears as a triumphal arch whose dimensions are halfway between the altar of Santa Maria delle Grazie and the altar of Purgatorio of Sant'Erasmo. Specifically, the structure is about 6 m high and 5.05 m wide and is framed between the two Corinthian semi-columns, in turn, 3.50 m high (smaller, therefore, than those of the altar of Santa Maria delle Grazie, but taller and more tapered than those of the altars of Purgatorio and Sant'Erasmo).

6.6. Altar of the Crocifisso

It still preserves (substantially intact) the altar stone, the pedestals, as well as the lower part of the two semi-columns and the central frame, which originally contained the wooden statue of Christ crucified.

The altar is characterized by decorative elements and architectural components (frames, moldings) that make it very different from the previous ones; in particular, this is the only case where the columns have an Attic base (with two tori and a central scotia). These peculiarities suggest that the altar was built by different masons or in a different period than the others.

The digital reconstruction began, as usual, from the semi-columns. In order to trace the original height, only three known data were used: the height of the pedestals (1.25 m), the diameter of the shafts at the imoscapo (0.36 m) and, above all, the tracks that the altar left on the structures behind (which are intact). In fact, the survey of the wall and the surviving part of the vault permits us to notice the marks left by the altar ashlars.

Therefore, the entablature must have exceeded by a few tens of centimetres the vault's impost plane. This clue suggests an overall height of about 5.80 m, compatible with semi-columns 3.60 m high, i.e. 10 times their diameter at the imoscapo.

Once again, therefore, the proportional rules by Vignola are respected, which is also confirmed by the fact that, assuming the semi-columns high h = 3.60 m, the height of the respective pedestals would correspond to 1/3 of h, while the height of the entablature (obtained by subtracting the height of the semi-column and pedestal to the measure of 5.80) would correspond to 1/4 of h. Considering that these dimensions fit the traces on the wall and at the same time are compatible with those reported in *La regola delli cinque ordini d'Architettura*, they were considered accurate enough to be used as a reference in 3D reconstructing the missing parts.

(a) (b) (c)

Figure 14: a) Altar of the Duomo of Condrò; b) Altar of Santa Maria la Vetere; c) 3D model of the altar of Crocifisso. In white, NURBS. In the original colours, photogrammetric mesh of the surviving parts.

Following this criterion, the top of the semi-columns and the entire entablature were modelled following the succession of moldings proposed by Vignola for the Corinthian order (in the absence of recognizable fragments that could suggest a more precise reconstruction).

Finally, as far as the internal frame of the altar is concerned, it was not modelled in the form of a round arch (just like in the other altars); in this case, the researchers hypothesized a simple rectangular frame, based on the surviving traces.

In carrying out this operation, the coeval altars of two Sicilian churches (Santa Maria la Vetere in Militello in Val di Catania and the Duomo of Condrò) were used as a reference (Fig. 14).

6.7. Main portal

The only surviving parts of the portal are the basalt threshold, the pedestal of the left pilaster strip, the left jamb, the three access steps and some traces of the right pedestal.

Overall, the decorative apparatus, in particular, the bas-reliefs of the pedestal (characterized by a vase surmounted by cornucopias, wheat ears and fruits) presents some analogies with the triumphal arch of the church of San Antonino in Militello in Val di Catania (Santagati, Lo Turco, & Garozzo, 2018) (Fig. 15).

These surviving elements allow to precisely determine the width of the portal, about 2.20 m. Furthermore, other isolated elements have been found, specifically a dozen bossages belonging to the arch. In this case, the 3D reconstruction was based on the Doric order, more compatible with the severe style of the ashlars.

The height of the entire portal (Fig. 16) was traced by using a possible modular grid obtained from the study of the façade (Fig. 17), whose profile was sketched considering the height of the surviving walls of the nave.

Following these indications, the total height of the portal would be about 5.50 m (a little more than 1/3 of the probable height of the façade).

(a) (b)

Figure 15: Comparison between a) the pedestal of the church of San Antonino in Militello in Val di Catania, and b) the portal pedestal of Santa Maria de Monasterio Albo.

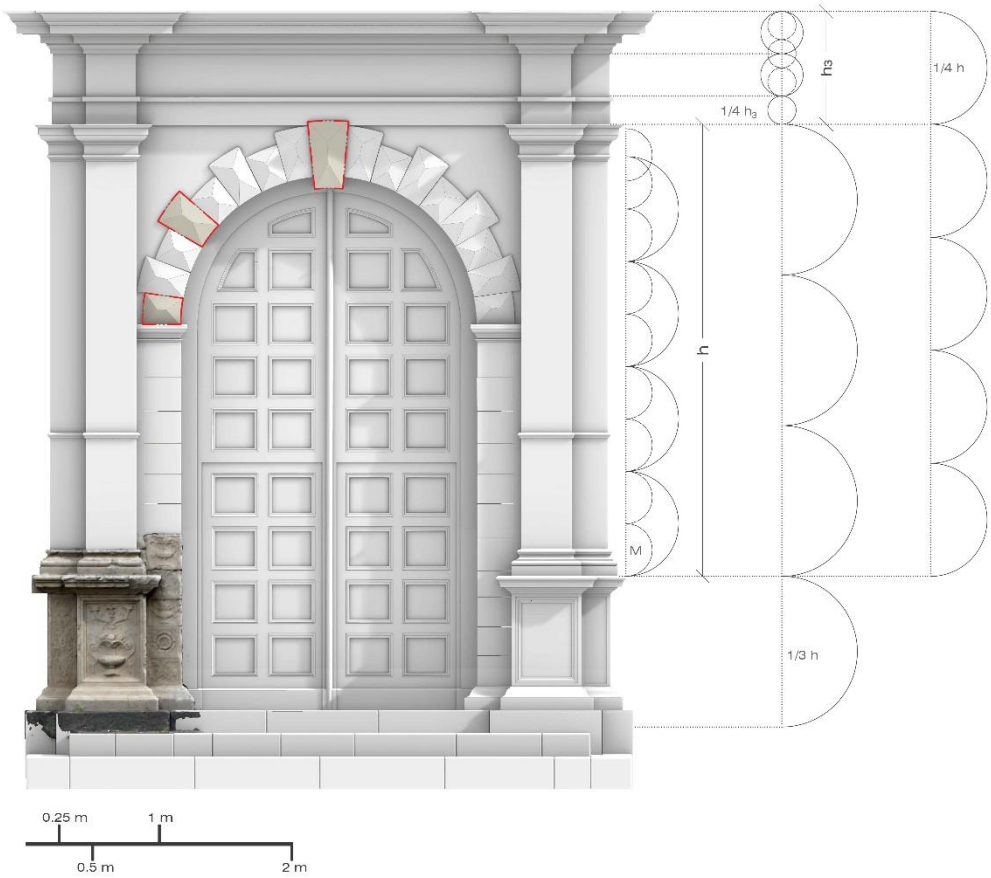

Figure 16: 3D model of the main portal. In white, NURBS. In the original colours, photogrammetric mesh of the surviving parts. In red, virtual anastylosis.

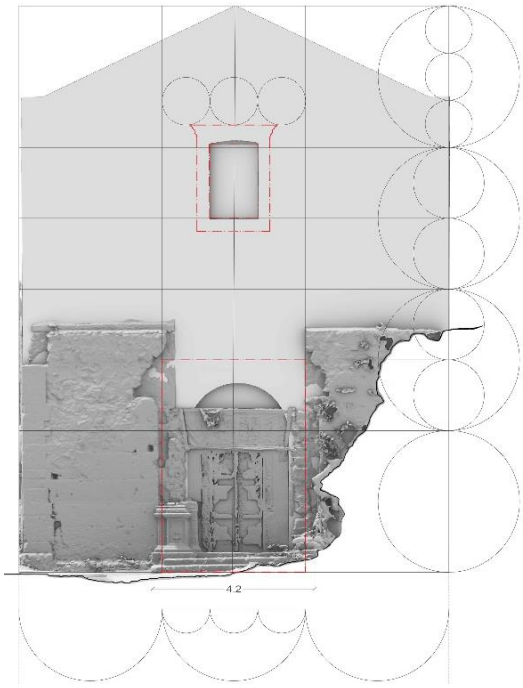

Figure 17: Possible modular grid of the façade.

This height is plausible, since it allows to realize some pilaster strips 8.5 times taller than their base, while the remaining space would be filled by a pedestal, equal to 1/3 of the height of the pilaster strips, and by an entablature, equal to 1/4 of the height of the pilaster strips. These proportions are consistent with the Doric order by Vignola; among the Renaissance treatises, in fact, Vignola is the one that proposes the most slender version of the Doric order, with a column height equal to 8 modules.

7. Discussion

This project can be considered as a part of the decades-long debate on the relationship between architecture, archaeology, restoration and new digital applications, which allow conveying the memory of the past through three-dimensional content (Pietroni & Ferdani, 2021). These technologies enable interventions that were unthinkable up to twenty years ago in terms of accuracy and realism, so it is essential to reflect on the multiple implications underlying this remarkable potential.

Specifically, the creation of digital replicas of the decorative apparatus of Santa Maria de Monasterio Albo has addressed the issues of restoration and virtual reconstruction. These two concepts, codified in the Seville Principles (Lopez-Menchero & Grande, 2011) and discussed in detail, inter alia, by (Pietroni & Ferdani, 2021), have different shades of meaning but also several similarities, especially when applied to sites with unique characteristics such as Santa Maria de Monasterio Albo. In this regard, the 3D models of the altars and the portal described in these pages can be considered as an

attempt to carry out a virtual restoration, as they allow to plan and support a possible physical restoration (through the virtual anastylosis, conceived as a tool to simulate a hypothetical real anastylosis) and try to reconstruct the figurative and stylistic unity that the artefacts have lost. In this context, the accurate classification of the isolated decorative fragments (whose original location has never been hypothesized so far) played a fundamental role in providing valid support for the hypothetical restoration interventions, partial anastylosis or even new museum exhibitions of the artefacts in the real world.

At the same time, however, it is possible (and perhaps even more appropriate) to speak of virtual reconstruction, since - unlike what usually happens in virtual restoration interventions - in this case, the studied artefacts are archaeological ruins, whose lost parts often prevail over the surviving ones, implying that reconstructive hypotheses have often played a predominant role (Pietroni & Ferdani, 2021).

As is the case with any virtual reconstruction, the present study also had to deal with the ethical problems associated with the creation of 3D models, in which it is often difficult to distinguish what is real and objective from what is only a more or less subjective interpretation or hypothesis. Undoubtedly, the virtual reconstruction of an archaeological ruin in its original configuration represents an extraordinarily useful and effective means of promoting knowledge of the site, fostering its legibility and contextualization and conveying educational content to those who access the 3D models. However, the debate remains open as to what is the proper way to ensure that the reconstruction is not a falsification devoid of scientific value.

Over 11 years after the establishment of the London Charter, the lack of standards in the field (although allows wide expressive freedom) implies that reconstructions are still prone to the subjectivity factor, related to the cultural background of the operator/scholar. The reliability and scientific rigour of the 3D reconstruction and the underpinning process are fundamental for releasing high-quality cultural products, which give back a lost identity and memory to communities.

In this regard, the methodology developed in this paper has attempted to combine the scientific rigour with the need to provide a clearer overview of a place (the church of Santa Maria de Monasterio Albo) that is still enigmatic. The research thus shed light on several unsolved issues, showing the remarkable potential of virtual reconstruction in the field of documentation, conservation and promotion of cultural heritage. Specifically, for the first time, it was possible to elaborate reliable and rigorous theories on the dating of the altars and to acquire a precise idea of the original configuration of the entire decorative apparatus, which showed particular affinities with the Mannerist style of the early 17th century and possible influences indirectly borrowed from Renaissance treatises.

The geometrical study, which involved the proportional and modular investigations, provided often the right key to complete the reconstruction, as in the case of the main façade. In particular, the rules of the classical orders deduced from the treatises had a fundamental role in guiding the reconstruction of the altars and the portal.

Finally, the study of the original archival documents (kept in the Diocesan and State Archives of Catania), together with the compared study of other coeval artefacts, played a crucial role in the considerations about the dating of the architectural and decorative elements.

Another relevant topic arisen during this research (and connected to the already mentioned ethical issues) is the importance of paradata (Brusaporci, 2017), i.e. all the information describing how the "invisible" memory of a lost artefact has been digitally reconstructed and how the sources at the basis of the reconstruction have been interpreted. In this sense, linking paradata to the model is a core step. Therefore, the research team is currently elaborating a classification of the paradata, in order to define the levels of reliability in the digital reconstruction. These paradata spans from the existing elements (highest level of accuracy), to the elements reconstructed from written/iconographic/photographic sources, to elements taken from the treatises or graphical analysis, to compared analysis with similar and coeval artworks, to conjectural assumptions based only on arguments. It is envisioned to link the classified paradata to the 3D models.

8. Conclusion and future works

The present research described the virtual reconstruction project of 6 altars and the main portal of the church of Santa Maria de Monasterio Albo, located in the ancient village of Misterbianco, nowadays known as Campanarazzu (CT, Sicily). These artefacts, partially destroyed during the 1669 eruption and brought to light during various excavation campaigns conducted in the 2000's, represent a rare example of Mannerist art in eastern Sicily. In order to document their extraordinary artistic value, the researchers digitally reconstructed the altars and the portal, ideally bringing them back to their condition immediately before the eruption. This goal was achieved through an elaborate workflow that, starting from in-depth archival research and two integrated digital survey campaigns (laser scans and photogrammetry), ended with the 3D modelling.

The results of this study will be the basis for future experimentations. In this regard, it is planned to extend the 3D reconstruction to the entire building, investigating many questions currently unsolved (height of the nave, ceilings, appearance of the bell tower, appearance of two altars not reconstructed due to lack of information, nature and location of further fragments belonging to the decorative apparatus).

A next step will consist in creating an informative 3D model; this means to associate to the 3D model an accessible database, containing information on the levels of reliability of the reconstruction, the followed methodology and the sources used as a reference in the reconstruction (paradata).

It is also planned to implement a diachronic 3D model of the church, conceived to show the main changes that the building underwent over the centuries. The diachronic model will be usable on online platforms, designed to share 3D models with both the scientific community and the common users.

Further experimentation will be carried out, with the aim of studying innovative ways (VR, AR, MR applications) to explore the archaeological site through the 3D model.

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