Information Models to Manage Complexity for an Integrated Knowledge Project

Raissa Garozzo, Massimiliano Lo Turco, Cettina Santagati

Abstract

The study aims to identify optimal workflows to create information models oriented to the management and the knowledge of architectural heritage in a state of ruin, through the analysis of the critical issues found in the parametric modeling of the existing artifact. The methodology is aimed at analysing possible criteria for the enhancement of the data detected in the transition from point cloud to a semantic model, and the management of the level of graphic detail (LoG, Level of Geometry) and information attributes (LoI, Level of Information), in order to define possible procedures to measure the Level of Reliability of the survey. The case study is the Mother Church of the ancient Misterbianco (Catania), one of the rare surviving vestiges of the eruption of Mount Etna in 1669 and the earthquake in Val di Noto in 1693. Thanks to its state of preservation and its cultural relevance, it represents the ideal case study for the proposed experimentation. (R.G., M.L.T., C.S.)

Parole chiave: laser scanning, photogrammetry, 3D modeling, H-BIM, Levels of Accuracy and Reliability.

Introduction

The documentation and conservation of Cultural Heritage plays an essential role in the transmission to future generations of the unique and universal values it represents. Tangible and intangible values that testifies to the tenacity and resilience of men in case of catastrophic natural events, such as eruptions and earthquakes. The case of eastern Sicily is emblematic, because it was affected, at the end of the seventeenth century, by two significant events that erased centuries of historical evidence: the eruption of Mount Etna in 1669 and the earthquake of Val di Noto in 1693. The collection of the few fragments of memories is so complex and meaningful that requires new approaches using information models and structured databases. These are knowledge-based system useful to know and better understand this evidence, promoting the information exchange and the integration of complex data in the field of Cultural Heritage. Among the digital methodologies that allow a holistic approach in the construction field, BIM (Building Information Modeling) is a virtuous process which could relate virtual models of building components and alphanumeric databases [Bianchini et al. 2017]. However, the full maturity achieved by the building information modeling approach in new constructions domain, is not yet observable in the Cultural Heritage field, where there are only a few research experiences aimed at verifying the potentialities, setting out best practices and defining standards. This

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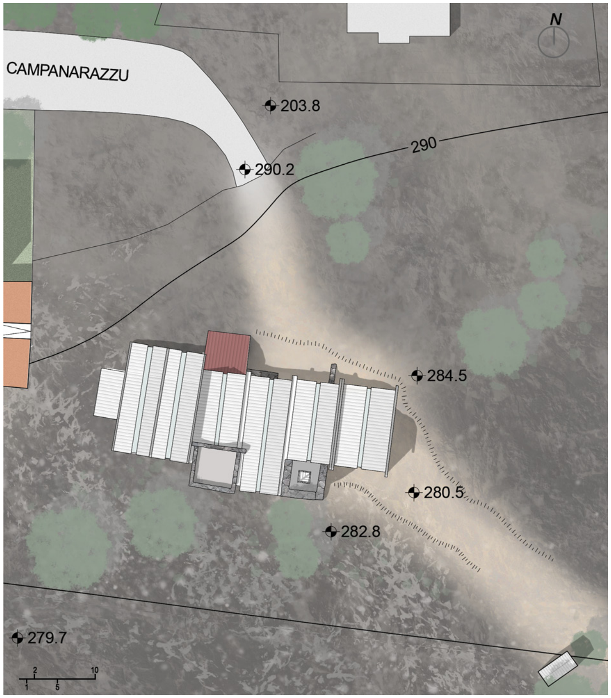


Fig. 1. General plan (graphic elaboration: R.G.)

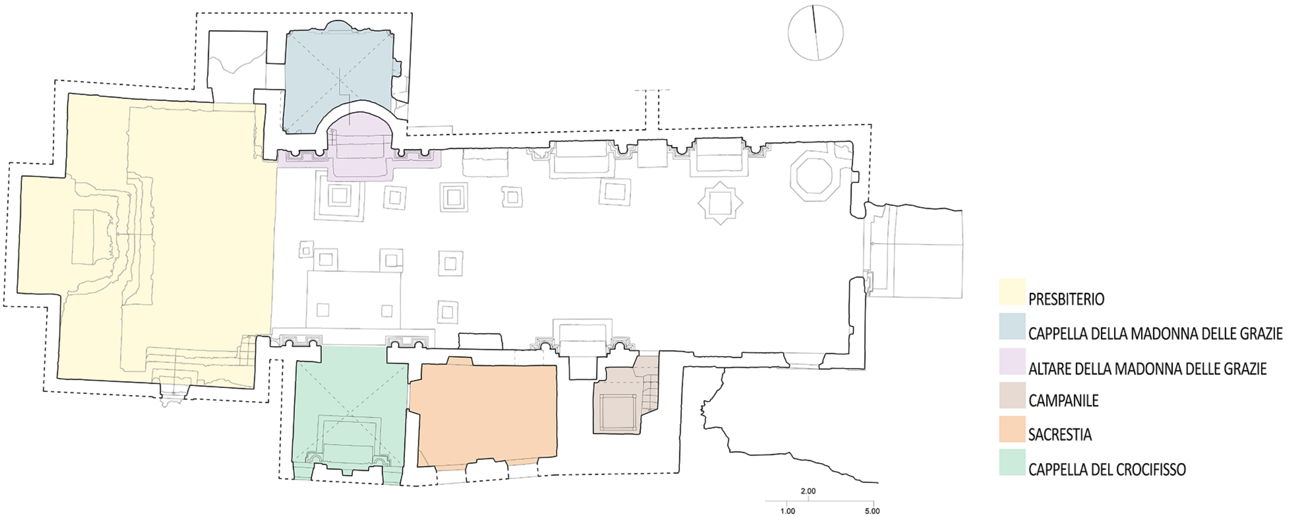
topic is still a frontier issue: the presence of irregular surfaces and complex decorative apparatus as well as the definition of very unique attributes, leads to time consuming activities in the setting-up of the model, due to difficulties which are not easy to solve and that shall be considered as relevant issues by the scientific community [De Luca, Véron, Florenzano 2007; Apollonio, Gaiani, Zheng 2015; Di Giulio et al. 2017]. The proposed methodology aims, therefore, to reason on possible criteria for the valorization of data through the measurement of the Level of Reliability (both geometric and semantic) [Bianchini, Nicastro 2018, p. 47] associated to the single component of the model and directly related to data conversion issues (level of geometric abstraction) and to the definition of the Level of Graphic and Informative Detail, according to the recent national legislation [UNI 11337: 2017]. (C.S.)

Related works

The current methodologies for architectural survey allow, through the integrated use of laser scanning and photogrammetric technologies, to acquire geometric/spatial data of the historical heritage. As such, they provide a 3D database that describes the surface of the building, recording information on the characteristics of the materials and their state of preservation [Bertocci, Bini 2012; Bianchini 2007]. The reverse modeling from point cloud to parametric geometric model is, however, still an open issue. Dealing with historical architecture, a critical point is the lack of specific semantic and parametric libraries [Fai, Rafeiro 2014]. Moreover, the definition of the level of geometric detail or the degree of adherence between the numerical model and its geometric abstraction becomes particularly complex in the presence of damaged, abandoned or very degraded artifacts, whose irregularities (out of lead, deformations, lacks) are part of the memory of the architecture and could provide information useful to define the structural setting or the state of conservation. The main characteristics of a BIM oriented approach can be summarized as follows: parametric intelligence, relationships and attributes [Barazzetti et al. 2015, p. 340]. In the literature some interesting works illustrate several approaches, adopting different applications for converting point clouds into intelligent parametric objects, introducing the concept of "level of accuracy" [Santagati, Lo Turco 2017, p. 011007-4; Biagini et al. 2016]. The very crucial phase refers to the difficulty of preserving the metric accuracy acquired by laser scanners and photogrammetric points' clouds, even in the infographic modelling phase. Defining the tolerance level of the modeling leads to the determination of the level of accuracy, in relation to the survey data; on this issue the references provided by legislation, guidelines and international standards are poor. A definition of the level of accuracy may be found in COBIM2012 - series 2 [Rajala 2012, p. 6]. Such document has introduced the concept of BIM Inventory and its level of precision, where tolerance (which may vary for specific systems/components of the building and it's expressed in ±mm) refers to the quantitative measurement of the deviation between the point cloud and the model. Similarly to the "Modelling tolerance" defined in Great Britain [Historic England 2017] or to the "Level of precision"

Fig. 2. The site during the excavation a) a view from above, b) excavation of the "gothic" chapel, c) consolidation of walls (pictures: G. Sciacca)

Fig. 3. Plan of the church (graphic elaboration: R.G., C.S.)



explicit in the requirements of the Finnish CoBIM [Rajala 2012, p. 11], we refer to the levels of LoD (Level of Development) for restoration, as defined by the Italian legislation. In this direction, a new approach for the modeling of historical buildings that takes into account the critical issues related to the conversion of 3D survey data and the possibility of having flexible LOD is given by [Banfi 2016, pp. 116-118],], which proposes the concept of ReversLOD. Other studies may refer to a "rigorous BIM" [Barazzetti et al. 2015, p. 340],], in which the focus key refers to a topic that is sometimes underestimated: in the field of historical construction the adoption of the BIM methodology should not be considered only on geometric precision, but requires more careful consideration, also considering other variables specific to an information system: parametric objects, relations, attributes, correct definition of the level of graphic detail (Level of Detail / GraDe / Graphic Detail, renamed in the Italian legislation in LoG, Level of Geometry) and information (LoI, Level of Information, as illustrated in the Italian legislation) [Brumana et al. 2018]. A virtuous organization of the compendium of information regarding Cultural Heritage is crucial; the methodologies in the realization of models usable and related to databases that may be easily readable and updated is one of the main objectives carried out in cooperation between the Scientific Community and the professional world: a model developed for the architectural heritage may constitute to all the intents and purposes a database organized in a coherent manner, in which the different aspects of management, enhancement, maintenance and conservation are mutually related through parameters. (C.S.)

The Church of Santa Maria delle Grazie in the ancient Misterbianco

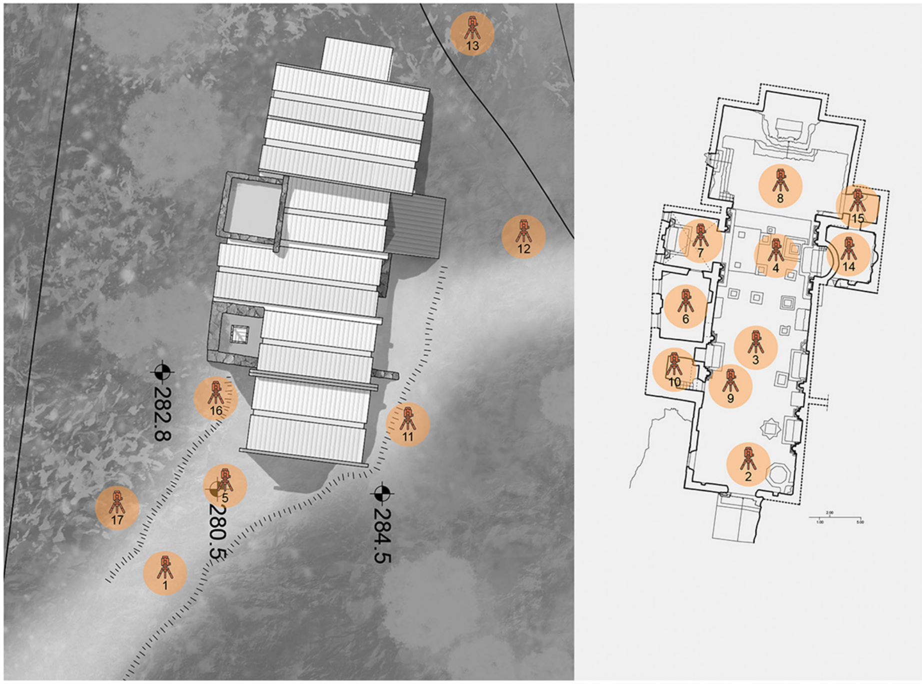
The following study refers to the Mother Church of the ancient Misterbianco (Catania), identified as a very interesting case study due to its unique state of preservation (unleaded walls, deformed flooring, original wall texture overlaid by today's integrations). Located 5 km north-east of the current town, the remains of the ancient place of worship dedicated to the Madonna delle Grazie preserve traces of historical and architectural memory from the fifteenth to the seventeenth century. Just very

Fig. 4. Views of the church: a) the main façade, b) the interior of the nave (pictures: R.G., C.S.)

few examples of this type remain in south-eastern Sicily, tragically marked by the eruption of 1669 and the earthquake of Val di Noto in 1693. Preserved under the 12 metres of lava that buried it and the ancient town of Misterbianco in 1669, the church, identifiable thanks to the vestiges of the bell tower soaring the lava landscape until 1693 big earthquake (hence the name Campanarazzu of the locality), has always aroused the interest of curious and scholars [Politano, Santonocito 1999, pp. 156-157]. Starting from 2002 till 2015, the site has been interested by excavations and consolidation works carried out by the Soprintendenza ai Beni Culturali e Ambientali di Catania, that brought the layout of the church to the light, enabling the access to visitors (figs. 1, 2). The church, whose longitudinal axis is arranged along the east-west axis, was reached by a staircase leading to the main portal located to the east side. The building, still partially gripped by lava stone, has a single nave, just over 26 meters, ending with a large presbytery apse (9x13 meters), slightly raised, which hosts the main altar (fig. 3).

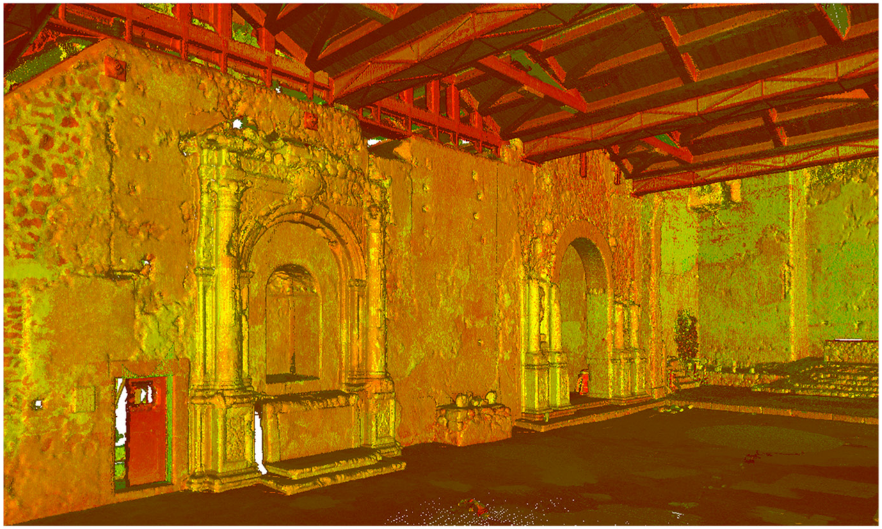
On the southern front there is the access to the bell tower and the chapel of the Holy Crucifix, a quadrangular vaulted room connected to a room probably used as a sacristy. On the northern wall, concealed by the niche of the imposing altarpiece that housed the marble statue of the *Madonna delle Grazie* (realized by Gaginian school), there is the so-called "gothic" chapel, the oldest nucleus of the church, accessible by a side hallway of the presbytery and an eastern additional room, currently occluded [Santagati, Mondello, Garozzo 2017; Garozzo 2018]. The nave is adorned by eight altars, five of which preserve a substantial part of the altarpiece of seventeenth-century Mannerist style; to these may be add the monumental decorative structure of the access to the chapel of the Holy Crucifix (fig. 4). The floor of the nave, in hexagonal terracotta tiles, holds thirteen tomb slabs which close the corresponding vaulted sepulchral chambers below.

Fig. 5. Laser scan project (graphic elaboration: R.G.)



Scans	Number of points	Targets
1	4.041.796	6
2	10.841.885	6
3	16.874.188	-
4	12.956.703	-
5	4.629.414	-
6	5.269.019	-
7	4.422.367	-
8	10.182.513	-
9	1.451.366	-
10	5.732.248	-
11	4.009.638	-
12	4.769.934	-
13	4.268.328	-
14	5.224.888	-
15	6.563.334	-
16	2.546.830	-
17	3.638.050	-
Total	107.422.501	6

Leica HDS 3000



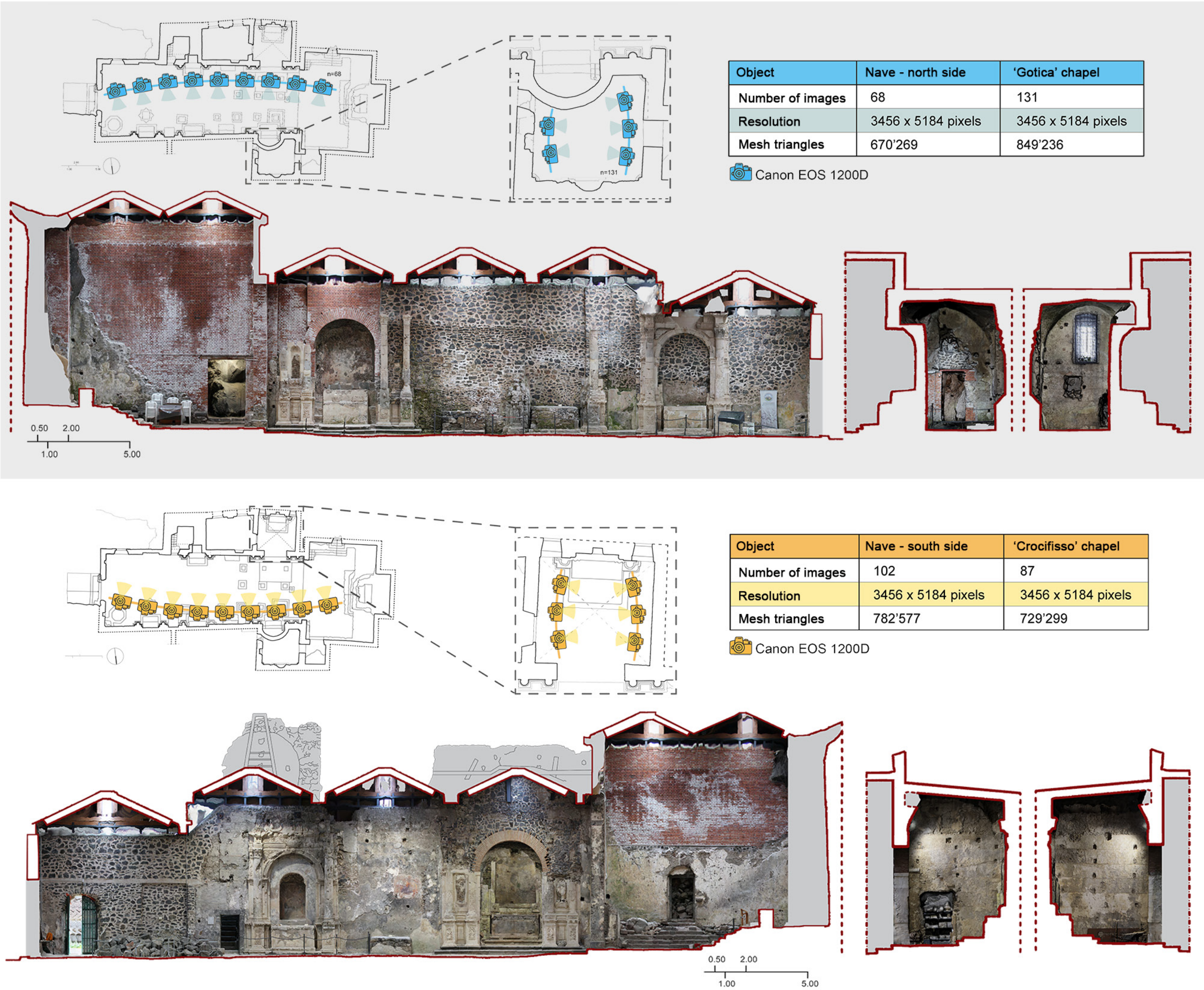
From survey to infographic representation: between interpretation and interoperability

The geometrical, morphological and formal features of the case study required an approach using integrated digital technologies, such as laser scanning (fig. 5) and photogrammetry. The Leica Geosystem HDS 3000 laser scanner was used, with 17 scans – 7 external and 10 internal – for a total of 107 ML of points, then aligned through 6 spherical and homologous targets. The alignment error is 3 mm. The scans have been processed to be used in the most common BIM platforms, as a metric reference for subsequent modeling. Moreover, several photographic datasets have been acquired, in order to integrate the acquired scans, using photogrammetric techniques (fig. 6). Since this building is characterized by many geometric irregularities (deformations, missing parts), an in-depth analysis has been carried out in order to define the proper level of geometric accuracy of the model, to evaluate the opportunity to effectively use systems and procedures created for the standardization of building components in the presence of complex architectures, to reconcile the study purpose with the documentation and management of the architectural asset. Each building component of the church (walls, floors, openings, vaults, altars) shows the signs of the impact of the lava flow and the subsequent contemporary attempt to redefine a spatial coherence to the building (through the reconstruction of part of the walls, for instance) after the excavation. It was considered fundamental, therefore, to preserve all these particularities of the model, both from a geometric and informative point of view. It made necessary to carry out an experimentation to identify, on a case-by-case basis, the most suitable workflow to pursue the objectives set out above. One of the major problems revealed was the lack of interoperability between the different software platforms used, since the modeling was not conducted exclusively within the chosen BIM platform. In order to preserve the documentation of the deformations affecting the floor of the nave (about 20 cm), two different workflows have been tested. The first one involves the use of a plug-in (PointSense for Revit) to create range maps and profiles, with consequent deformation of the surface, initially simplified, according to a preset grid (fig. 7); the other one, considered more efficient than others in this case, involves the creation of a mesh converted into a NURBS surface and imported into the BIM platform for the characterization and the information enrichment. The same approaches have been tested on the walls (fig. 8); in particular, to simplify the modeling of wall geometry by keeping track of irregularities and out-of-plumb, we consider more efficient to rely on simplified modeling to enrich with depth maps and generated profiles of the plug-in (Pointsense for Revit). Finally, a specific reasoning was applied to the altars, which present several lacks due to the violence of the lava flow that invested them. A reconstructive geometric modeling would have lost trace of the missing parts, improving the graphic rendering of the model but erasing the signs of the eruption on the artifacts. It was therefore decided to import the mesh model, subsequently categorized through the plug-in (MeshImportfromOBJ), obtaining a high level of geometric accuracy of the surfaces, although the adopted solution generates outputs that take up a lot of memory and are difficult to be managed (fig. 9). Doing this, the obtained model preserves the peculiarities of the object of study, both from a geometric and informative point of view (fig. 10). (R.G.)

The reliability of the collected data, between measurement and semantic classification

An integrated survey implies a double control, by providing to relate the definition of the level of geometric accuracy, obtained in the phase of graphic restitution, with the modeling of the attributes, semantically related to the digital artifact and its components. Moreover, as mentioned above, the Italian legislation also distinguishes between LoG and LoI the different graphic and alphanumeric connotations of the BIM models. Therefore, not only the level of accuracy (LoA) but also the Level of Reliability (LoR) takes on a wider meaning, as broad and inclusive is the open system of knowledge that characterizes the operations of integrated survey. In the last years, it has been proposed an articulated system of numerical evaluation of the level of reliability of BIM models relating to existing architectures, taking into account the possible retrieval of archival and bibliographic data, several investigations about the building, knowledge of construction techniques, analysis of the construction materials, through a numerical evalu-

Fig. 6. Sections with orthophotos from photogrammetry (graphic elaboration: R.G.)

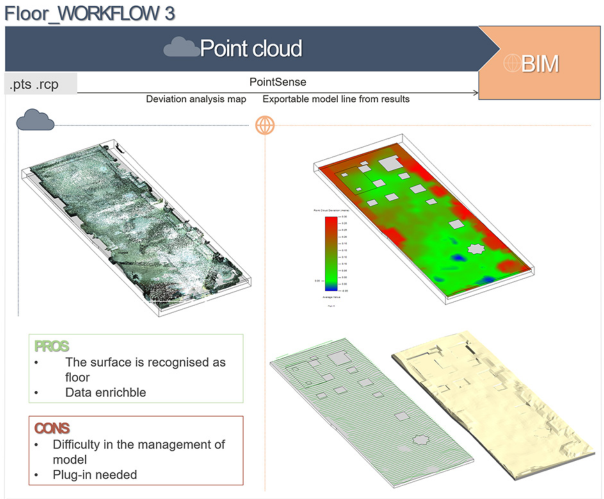


Object	Nave - north side	'Gotica' chapel
Number of images	68	131
Resolution	3456 x 5184 pixels	3456 x 5184 pixels
Mesh triangles	670'269	849'236

Object	Nave - south side	'Crocifisso' chapel
Number of images	102	87
Resolution	3456 x 5184 pixels	3456 x 5184 pixels
Mesh triangles	782'577	729'299

Fig. 7. Experimentation on the floor (graphic elaboration: R.G.)

Fig. 8. Experimentation on the wall (graphic elaboration: R.G.)



ation system consisting of parameters associated with the building components [Bianchini, Nicastro 2018, pp. 54-58]. In a similar manner, since the first activities carried out on the case study, it was proposed to populate the components detected with new attributes, through the preparation of specific parameters deriving from the survey operations carried out. The model and its components are defined by means of a dedicated list of shared parameters, in a logical sequence that provides to verify the presence of the data, the author and the date of its recording and a note field. These definitions take on different connotations according to the nature of the collected data or the technique used to make a particular measurement, including: presence of archival material; documentation attesting to any latter day additions by the asset: photographic survey, direct survey and construction of dimensioned sketches; photogrammetric survey; laser scanner survey; survey of finishing materials and degradation; invasive measurements. Unlike the approach proposed by Bianchini and Nicastro, at the moment we have focused only on the structuring of the attributes; therefore, we have not yet come to formulate a proposal for a quantitative measurement of the reliability of the detected artifact, even though the first evaluation grids have been formulated through the development of parallel research activities [Lo Turco et al. 2018, p. 2528]. The aim is to extend the experimentation to a significant number of experiences in order to systematise these processes, involving a greater number of researchers of the Scientific Community in the evaluation of the weight to be attributed to the individual instances and to the critical analysis of the proposed method. (M.L.T.)

Conclusions

This research aimed to verify the applicability of HBIM processes on a complex and ruined artifact, such as the church of Madonna delle Grazie in the ancient Misterbianco, reasoning on the verification of the metric and informative accuracy: the conversion from the numerical model, constituted by the point cloud, to a math-

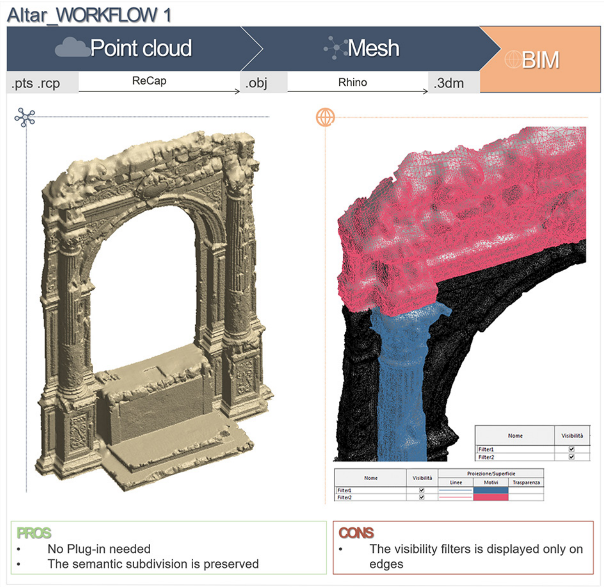


Fig. 9. Experimentation on the altar (graphic elaboration: R.G.)

Fig. 10. Axonometrical vertical sections of the model (graphic elaboration: R.G.)

ematical and semantic model is a process that involves simplifications and deductive hypotheses [Santagati, Lo Turco 2017, p. 011007-3]. However, the high level of detail is an essential feature of the information modeling process in the field of Cultural Heritage, since some singularities that characterize the historical architecture could acquire crucial relevance for subsequent interventions. Now, the processes of acquisition and infographic restitution are poorly automated and very time-consuming. It is therefore desirable that the Scientific Community works on the systematization of automation processes based on ontologies and on the semantic recognition of information, with a specific regard to the cultural heritage field [Messaudi et al. 2018]. A second theme concerned a critical examination of the definition of the "Level of Reliability" of the numerical model, through a new interpretation of the term "measurability", not only from a geometric point of view, but aimed at an ontological approach that structures and supports a quantitative evaluation of the degree of alphanumeric reliability of a survey. In this sense, the BIM methodology can be considered a bridge between the archival documentation and the digital model, especially if data description processes related to object-oriented formal language are activated. To give even more evidence to the collected documentary apparatus, it is necessary to create a shared work environment able to store and provide graphic and alphanumeric information through a direct association between the BIM environment and the formalization of ontologies. [Quattrini et al. 2017; Bonsma et al. 2018]. Through interoperable processes it is possible to figure out operational scenarios in which all actors can directly implement the recordings made in situ in an easy and accessible form. To do this, it is necessary to support the object-oriented paradigm with the conceptual aspects of relational approaches useful for the management of heterogeneous, numerous and constantly updated data. From a scientific point of view, the application of these tenets will allow to address and define new methodologies for the knowledge (and representation) of Cultural Heritage through more transparent processes. Finally, a last consideration on integrated approaches of analysis and design is proposed, leading to new forms of representation, which expand the frontiers of our discipline in the direction of a greater formal qualification and in the permanent relationship between architectural space and information space. (M.L.T.)

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Reference list

Apollonio, F.I., Gaiani, M. Zheng, S. (2015). BIM-based Architectural Heritage Management: A Case Study of Palladio's Palazzo Barbaran da Porto. In *E-Sharing Cultural Heritage*. Atti del *Second International Symposium on Cultural Heritage Conservation and Digitization*. Beijing, 17-19 ottobre 2012, pp. 101-115. Shanghai: Shanghai Far East Publishing.

Banfi, F. (2016). Building Information Modelling – A Novel Parametric Modeling Approach Based on 3D Surveys of Historic Architecture. In M. Ioannides, E. Fink, A. Moropoulou, M. Hagedorn-Saupe, A. Fresa, G. Liestøl, V. Rajcic, P. Grussenmeyer (eds.) (2016). In *Proceedings of the 6th International Conference EuroMed 2016 Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection*. Nicosia, 31/10-5/11/2016, part I, pp. 116-130. Basel: Springer International Publishing AG.

Barazzetti, L., Banfi, F., Brumana, R., Previtali M. (2015). Creation of parametric BIM objects from point clouds using NURBS. In *The Photogrammetric Record,* n. 30, vol. 152, pp. 339-362. <https://onlinelibrary.wiley.com/doi/10.1111/phor.12122> (consultato il 28 maggio 2019).

Bertocci, S., Bini, M. (2012). *Manuale di rilievo architettonico e urbano*. Novara: CittàStudi Edizioni.

Biagini, C., Capone, P., Donato, V., Facchini, N. (2016). Towards the BIM implementation for historical building restoration sites. In *Automation in*

Construction, n. 71, pp. 74-86. <https://www.sciencedirect.com/science/article/pii/S0926580516300425?via%3Dihub> (accessed 2019, May 28).

Bianchini, C. (2007). Laser Scanning X. In P. Paolini, E. Chiavoni (a cura di). *Metodi e tecniche integrate di rilevamento per la realizzazione di modelli virtuali dell'architettura della città*, pp. 24-31 Roma: Gangemi Editore.

Bianchini, C., Inglese C., Ippolito, A., Maiorino, D., Senatore, L.J. (2017). Building Information Modeling (BIM): Great Misunderstanding or Potential Opportunities for the Design Disciplines?. In A. Ippolito, M. Cigola (eds.). *Handbook of Research on Emerging Technologies for Digital Preservation and Information Modeling*. Hershey, PA (USA): IGI Global pp. 67-90.

Bianchini, C., Nicastro, S. (2018). La definizione del Level of Reliability: un contributo alla trasparenza dei processi di Historic-BIM. In *Dn.Building Information Modeling, Data & Semantics*, n. 2, pp. 46-59. <http://www.dienne.org/> (accessed 2019, January 22).

Bonsma, P., Bonsma, I., Ziri, A.E., Iadanza, E., Maietti, F., Medici, M., Ferrari, F., Sebastian R., Bruinenberg, S., Lerones P.M. (2018). Handling huge and complex 3D geometries with Semantic Web technology, In *Florence Heri-Tech – The Future of Heritage Science and Technologies*, IOP Conf. Series: Materials Science and Engineering, n. 364, 012041.

Brumana, R., Della Torre S., Previtali, M., Barazzetti, L., Cantini, L., Oreni D., Banfi, F., (2018). Generative HBIM modelling to embody complexity (LOD, LOG, LOA, LOI): surveying, preservation, site intervention – the Basilica di Collemaggio (L'Aquila). In *Applied Geomatics*, vol. 10, n. 4, pp. 545–567. <https://link.springer.com/article/10.1007/s12518-018-0233-3> (accessed 2019, May 28).

De Luca, L., Véron, P., Florenzano, M. (2007). A generic formalism for the semantic modeling and representation of architectural elements. In *The Visual Computer*, vol. 23, n. 3, pp. 181-205. <https://link.springer.com/article/10.1007/s00371-006-0092-5> (accessed 2019, May 28).

Di Giulio, R., Maietti, F., Piaia, E., Medici, M., Ferrari, F., Turillazzi, B. (2017). Integrated data capturing requirements for 3D semantic modelling of Cultural Heritage: the INCEPTION Protocol. In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. XLII-2/W3, pp. 251-257.

Fai, S., Rafeiro, J. (2014). Establishing an Appropriate Level of Detail (LoD) for a Building Information Model (BIM) – West Block, Parliament Hill, Ottawa, Canada. In *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. II-5, pp. 123-130. <https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/II-5/123/2014/> (accessed 2019, May 28).

Garozzo, R. (2018). *La chiesa Madre dell'antica Misterbianco in contrada Campanarazzu - Reverse Building Information Modeling per un progetto integrato di conoscenza*. Tesi di laurea in Ingegneria Edile-Architettura, relatore C. Santagati, correlatori M. Lo Turco, A. Mondello, G. Sciacca. Università degli Studi di Catania.
Historic England (2017). *BIM for Heritage. Developing a Historic Building Information Model*. Swindon: Historic England. <https://historicengland.org.uk/images-books/publications/bim-for-heritage/heag-154-bim-for-heritage/> (accessed 2019, February 18).

Lo Turco, M., Parisi, P., Gómez-Blanco Pontes, A., Rivas López, E. J. (2018). Modelli HBIM per la valorizzazione e gestione del patrimonio culturale. Il caso studio dell'Escuela Tecnica Superior de Arquitectura di Granada, In F. Minutoli. *Atti del VI Convegno Internazionale sulla Documentazione, Conservazione e Recupero del Patrimonio Architettonico e sulla Tutela Paesaggistica ReUSO 2018. L'intreccio dei saperi per rispettare il passato interpretare il presente salvaguardare il futuro*. Messina, 11-13 ottobre 2018, pp. 2519-2530. Roma: Gangemi editore.

Messaoudi, T., Véron, P., Halin, G., De Luca, L. (2018). An ontological model for the reality-based 3D annotation of heritage building conservation state. In *Journal of Cultural Heritage*, vol. 29, pp. 100-112. <https://www.sciencedirect.com/science/article/abs/pii/S1296207417304508> (accessed 2019, May 28).

Pavan, A., Mirarchi, C., Giani, M. (2017). *BIM: Metodi e strumenti. Progettare, costruire e gestire nell'era digitale*. Milano: Tecniche Nuove.

Politano, F., Santonocito. F. (1999). Ruins of ancient "Campanarazzu" buried by 1669 eruption. In *Inside Volcanoes, IXth International Symposium On Vulcanospeleology of the I.U.S.* Catania, 11-19 settembre 1999, pp. 156-160.

Quattrini, R., Pierdicca, R., Morbidoni, C., Malinverni, E.S. (2017). Conservation-oriented hbim. The bim explorer web tool. In *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. XLII-5/W1, pp. 275-281.

Rajala, M. (2012). *COBIM - Common BIM Requirements 2012 Series 2. Modeling of the starting situation*. <https://buildingsmart.fi/wp-content/uploads/2016/11/cobim_2_inventory_bim_v1.pdf> (accessed 2019, February 18).

Santagati, C., Mondello, A., Garozzo, R. (2017). La Chiesa di Santa Maria delle Grazie dell'antica Misterbianco: la conoscenza della fabbrica tra rilievo, rappresentazione e documentazione. In *Tecnica e ricostruzione*, vol. LXVII, pp. 50-55.

Santagati, C., Lo Turco, M. (2017). From structure from motion to historical building information modeling: populating a semantic-aware library of architectural elements. In *Journal of Electronic Imaging*, n. 26, pp. 011007.1-12. <https://www.spiedigitallibrary.org/journals/Journal-of-Electronic-Imaging/volume-26/issue-01?SSO=1> (accessed 2019, May 28).

UNI (2017). *UNI 11337:2017. Edilizia e opere di ingegneria civile – Gestione digitale dei processi informativi*. Milano: UNI.