

MULTI-SCALE DIGITAL SURVEYING STRATEGY FOR DOCUMENTING AND DISSEMINATING THE HISTORY OF THE CHURCH OF SAN GIORGIO IN SALERNO

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Abstract

The paper reveals the outcomes of research efforts aimed at documenting lesser-known religious architectures using virtual databases created from a variety of digital surveying technologies employing a multi-scale approach. Through experimental research conducted on the Church of San Giorgio in collaboration with the Archdiocese of Salerno-Campagna-Acerno, this study highlights the transformative impact of technology on preserving the city's cultural heritage. This involves streamlining documentation procedures and improving heritage management practices. Moreover, this integrated and interdisciplinary approach holds promise in facilitating decision-making processes related to conservation, restoration, and maintenance efforts. The outcomes of this research are shared with both academic and public audiences, fostering greater awareness and appreciation of Salerno's religious heritage.

Keywords

Ecclesiastical Architecture, 3D Modelling, Transdisciplinary Approach, Integrated Point Cloud, Virtual Tour.

1. *Visualising History: Graphic approaches in heritage preservation*

In the realm of cultural appropriation of architectural heritage, the graphic approach stands as indispensable for conducting critical analyses and achieving precise interpretations of physical spaces or urban environments. Engaging with a place extends beyond passive "observation", and a meticulous examination to grasp the essence of the studied reality is needed (Florio, 2020). Through the accurate creation of signs and drawings, both the tangible and intangible aspects of a space can be carefully addressed, measured, and portrayed in geometric and morphological terms. This allows a comprehensive analysis from different perspectives, highlighting elements such as technological and material attributes, preservation status, and historical evolution. Consequently, an amount of data and knowledge from various disciplines converge to generate objective representations that visually capture the subject of study. Hence, the translation of intricate realities into geometric and visual models is facilitated through the application of a technical language rooted in a robust framework of principles and standards.

Drawing, traditionally used for accurate and scientific representation of reality, is now recognized for its potential in communicating and disseminating cultural heritage. This shift is driven by the increasing acceptance of sophisticated infographic techniques and processes, spurred by digital transformation. This development has fundamentally altered the interaction between architectural or urban spaces and their users, introducing to new models for understanding reality, particularly within the realm of historically significant built heritage (Giordano & Huffman, 2018). The cultural appropriation of architectural and urban heritage is, in effect, facilitated by the transmission of data and information through virtual or immersive images, which possess a potent visual impact. Infographics have a unique ability to engage a broader audience beyond technical professionals, eliciting cognitive responses that delve deeper into the studied reality beyond mere spatial measurements. Digitality acts as a catalyst for reimagining the paradigms and systems governing cultural heritage management, moving beyond mere data storage and processing to redefine how individuals perceive, access, and relate to art and architectural history (Jin & Liu, 2022; Parrinello, Sanseverino, & Fu, 2023).

Therefore, digital transformation should be seen as an opportunity to create growth and improve the economic and social value of the community, rather than as a technological necessity. In this sense, advances in technology makes it easier to face new challenges; however, it is the critical contribution of research that allows cultural heritage to be fully appreciated in its physical, digital, and cognitive dimensions.

1.1 Transdisciplinary and plural figures involved in the research

Starting from these considerations, this contribution presents a research endeavour focused on selected episodes of the ecclesiastical heritage of Salerno, involving the researchers from the “Laboratorio Modelli - Surveying and Geo-Mapping for Environment and Cultural Heritage”. In particular, as part of an agreement between the Civil Engineering Department of Salerno University and the Archdiocese of Salerno-Campagna-Acerno, aimed at advancing knowledge of the churches within the Archdiocese, the use of digitality as an approach for the representation and documentation of the ecclesiastical architectural heritage was considered of fundamental importance. Since the main objective is to document, analyse, monitor, protect, and valorise, in a linked and coordinated way, the ecclesiastical heritage of the region, is required a collaboration between various scientific sectors of the Department, following a transversal and integrated digital approach.

So, addressing the Curia’s imperative to devise integrated forms of management and preservation for the ecclesiastical heritage under its jurisdiction, it was deemed crucial to propose a multidisciplinary cognitive approach starting with rigorous documentation. In this sense, various surveying and data digitization experiments were conducted to graphically document the architectural religious heritage, with a view to fostering public engagement.

Within the broader corpus of studied heritage, the Church of San Giorgio serves as an invaluable case study for testing proposed research methodologies. The architectural-artistic complexity of the building (Figs. 1-3), coupled with its modest size, limited historical documentation, and lack of community awareness, present a compelling opportunity to start initiatives aimed at rediscovering this remarkable example of Salerno’s Baroque architecture (Bergamo, 1973).

The digital reconstruction of the Church of San Giorgio in Salerno, therefore, serves as the focal point of this article. Dating back to Langobard origins and later transformed into Baroque style in 1674 (Natella, 1985), this monument is now regarded as one of the city’s most significant religious buildings. However, despite its importance, there are evident shortcomings in its conservation procedures, knowledge, and documentation.

The activities involving the church, conducted thanks to the support of the Alfano I Foundation and the Rectory of San Giorgio, encompassed historical-graphical documentation, surveying, monument modelling, and the creation of virtual tours, all aimed at conveying information to the community in an engaging and accessible manner.

The strategy adopted focuses on enhancing public understanding of the sacred structure by disseminating knowledge in accessible, non-specialized formats, underpinned by rigorous documentary research (Brusaporci et al., 2021).

Researchers actively engaged in various phases of analysis, interpretation, and data processing using digital tools.

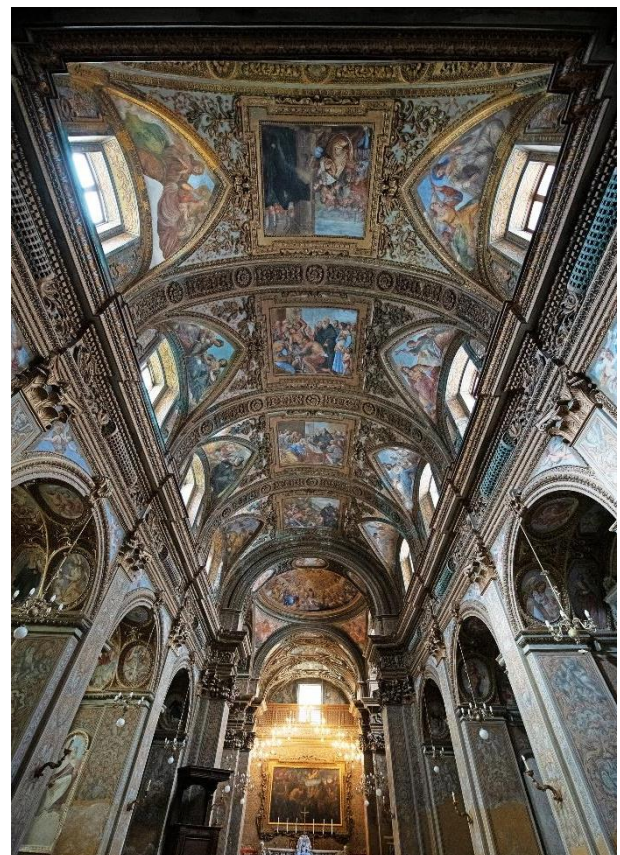


Fig. 1: Interior of the Church of San Giorgio in Salerno, decoration of the vaulted ceiling of the nave.



Fig. 2: Interior of the Church of San Giorgio in Salerno, view from below the dome on the transept.



Fig. 3: Interior of the Church of San Giorgio in Salerno, left side chapels.

The research began with interdisciplinary investigations involving Drawing and History of Architecture teams. This phase implied the retrieval of archival sources and documents essential for comprehending the architectural space and urban context (Crisci & Campagna, 1962; Caputo, 1988; Braca, Pasca & Carafa, 2000). These resources served as a foundation for reconstructing the monument through surveying and digital representation technologies. To facilitate visual documentation, a comprehensive three-dimensional metric survey protocol was developed, aiming to establish a repeatable approach applicable not only to the Church of San Giorgio but also to other ecclesiastical objects under examination.

1.2 Dissemination strategies for cultural heritage

The transformation of the processes of reading and graphic transposition of historical information is a highly topical issue, especially in the context of the digital transition that has currently affected the documentation and management of cultural heritage.

Although the digitisation of cultural heritage started systematically in the 1990s, achieving very high levels of representational fidelity over time, it is only in recent years that it is increasing, stimulated by co-creative science and the participation of a wide range of stakeholders in the new governance models (MiC, 2023). This growth has inevitably also affected the related surveying and representation procedures, implementing their various applications of both measurement and knowledge, emphasising the cultural, economic, and social value of graphic communication associated with information systems.

The adoption of key approaches and strategic measures launched at European level (European Commission, 2024) for the development of heritage policies and/or to protect heritage – together with the interruption of activities with the public and, more generally, of those aimed at disseminating heritage, caused, as we know, by the recent health emergency – has outlined a vast and varied panorama of the ways and reasons for the growth of digital graphic information (Poulopoulos & Wallace, 2022).

First of all, promoting the dissemination of knowledge through digital-based communication is one of the key aspects of the ‘vision’ of the “Horizon Europe 2021-2027 Research and Innovation Programme”, the European Union’s main funding programme for research and innovation, with a budget of EUR 95.5 billion (European Commission, 2024).

Another topical programme, part of the “Next Generation EU” fund, also known as “recovery fund”, is the “National Recovery and Resilience Plan” (PNRR), approved in 2021 for a green and digital development of the country. One of the strategic axes of the plan is, in fact, the “digitisation and innovation” of processes, products and services, factors recognised as fundamental for improving Italian competitiveness. Moreover, the first of the plan’s six specific components, called “Digitisation, Innovation, Competitiveness, Culture and Tourism”, proposes the digital transition by relaunching two of Italy’s characteristic sectors: tourism and culture. This highlights a desire to make up lost ground in terms of digital adoption and technological innovation, as underlined by the plan itself: in 2022, Italy would rank 18th among the 27 EU Member States according to the DESI (Digital Economy and Society Index), which monitors the digital performance and progress of EU member states in terms of digital competitiveness (European Commission, 2022). Finally, for Italy, the strategic framework to realise the objectives of the PNRR is the “Piano Nazionale di Digitalizzazione del patrimonio culturale” (PND): a useful methodological and operational reference for all cultural heritage institutions and operators, both public and private, to promote and organise the digital transformation process in the five-year period 2022-2026.

In this context, we will limit the discussion to aspects of the use and valorisation of the heritage in the fields of representation and architectural history, considering these themes as the basis for a wider accessibility and better usability of the cultural heritage. In this sense, with reference to the historical building, it is necessary to define the different approaches in which the products of the cognitive moment of the work are poured. This means identifying ways of communicating even the most technical information concerning the building, from its original characteristics to its entire evolution, such as dimensional, formal, spatial and construction values.

The primary technological basis for the emerging visual form is provided by highly integrated computer and information technologies, which give rise to the 3R technologies represented by VR (Virtual Reality VR, Augmented Reality AR, and Mixed Reality MR). These technologies essentially realise a digital simulation of cultural heritage, moving it from

physical space into cyberspace, with the potential for immersive experiences. In addition to spatial perception and interactivity, their function is extended by the ability to incorporate broad attributes and layers of information, thus visualising cultural value in multiple dimensions. This approach can be seen as a container or glue, as it includes and binds several purposes aimed at implementation: participation and inclusiveness; understanding and appreciation; sustainability and preservation of cultural heritage. In relation to these aspects, as noted by UNESCO recommendations, there is a contentious discussion about the growing importance and function of cultural spaces in contemporary society, with a focus on making them more inclusive and participatory environments. This is a challenging task since it seeks to consider a wide range of usability factors, including multisensoriality (Ansaldi, 2020), while also reflecting on the expectations and level of satisfaction of a very diversified audience. And occasionally it is a “non-public” (Miglietta, 2017), i.e., a significant number of people who, although for various reasons, do not visit museums; these reasons are typically related to a lack of information and/or bad experiences in the past, a lack of free time, an imbalance between cost and cultural products and services, and accessibility limitations, both specific and general.

It is therefore evident that the establishment of a comprehensive, diversified, and accurate graphical information base that can meet these needs at different levels of detail and that can also offer new insights becomes essential. Thus, the researcher finds himself framed within this chain, first as a surveyor for the design and implementation of technical solutions for digitisation, then as a 3D designer for the faithful restitution of models and the study of content dissemination; digital techniques linked to three-dimensional representation (surveying, modelling, 3D printing) combined with software design can offer a diversified response, introducing new actions, in the multiple diversity of supports and formats (Benedetti, 2020).

2. *Historical research, between lack of documentary sources and interdisciplinary work*

The Church of San Giorgio is located in Salerno, a city of significant historical and artistic importance within the Campania Region. Salerno, with its Roman origins and rich heritage, has been a prominent centre since the early Middle Ages.

Notably, it housed important monasteries located in the area known as “Plaium Montis”, situated north of the city centre, protected by fortifications and near the castle (Galante, 1997).

While the earliest mention of the settlement of San Giorgio dates to 819, some scholars have speculated, based on certain sources, about the potential involvement of the Lombard duke Romuald II in its establishment around 719 (Cassese, 1950). The congregation then developed over the centuries to become one of the most flourishing female Benedictine nunneries of the time (Crisci & Campagna, 1962). It housed the nuns of Salerno’s high society and served not only as a place of prayer and spiritual reflection but also as a centre of education, culture, and social assistance.

Very few structural and decorative elements remain today of the first Church of San Giorgio, which stood at the centre of the monastery. In fact, the building has undergone major renovations and transformations over the centuries, making it an interesting example of many historical and artistic layers. The very orientation of the east-facing medieval church has been completely reversed. Today we can see – using a motorised system that lifts the floor and uncovers the lower level – the remains of the original apse located near the current entrance to the sacred place.

The suppression and reunification of several women’s monasteries in Salerno in the late 16th century led to major changes in the structure of the San Giorgio complex, where nuns from other Benedictine institutes were at the time accommodated. It was therefore necessary to increase the capacity of the convent and enlarge its church, which was thus demolished and rebuilt following the guidelines of the Catholic-Reformation. Before the official opening ceremony of the new building, which took place in 1674 as can be seen from the date engraved on the counter façade, several works had already given the church a new face. Of clear Renaissance character were the modern entrance portal dated 1560 and the imposing hemispherical dome, symmetrical and supported by four discharge arches (Villani, 2020).

All the renovations, although substantial, had not altered the original construction to any great extent. The columns, that originally partitioned the space into three naves, were incorporated into the masonry pillars, which, extending as far as the side

walls, transformed the church into a single room, with a nave and small side chapels. It was later decorative works by the Avellino-born painter Angelo Solimena, in collaboration with his son Francesco, that gave the interior spaces a strongly Baroque look, which can be seen, for example, in the decoration of the dome, carried out between 1670 and 1680 and famous with the title “Paradiso Salernitano” (Caputo, 1988). Then as today, opulence and decorative richness emanated everywhere in the building’s interiors, embellished with gilded stuccoes, polychrome marbles, frescoes, and paintings, most notably the one depicting San Giorgio killing the dragon, an icon of 18th-century Italian Baroque (Corsari, 1974).

The collapse of some of the monastery’s structures in the early 18th century, resulting partially from the 1688 earthquake, had prompted the abbess to call for urgent action (Cantone, 2003). The renovations carried out by the Neapolitan architect Ferdinando Sanfelice during the first half of the 18th century on the entire monastery characterised the church’s architecture stylistically and structurally (Natella, 1985; Braca et al., 2000). For example, the construction of the vaulted pronaos in front of the portal has been dated to the time of Sanfelice’s presence in Salerno, i.e. around the 1710s (Natella, 1985). All these reconstruction works undoubtedly contributed to making this religious building a significant example of Baroque architecture in southern Italy.

Escaped from suppression during the French occupation (Perone, 2003), the Benedictine monastery of San Giorgio was closed after the unification of Italy: the monastic structures became State property (Fig. 4) and used as military barracks (Galante, 1997), while the church was handed over to the Municipality of Salerno¹ with the obligation to guard it and preserve its works of art (Crisci & Campagna, 1962).

The wartime actions of 1943 caused significant damage to the worship building, particularly to the structure and roofing, requiring major repair work, to prevent further damage to the numerous works of art preserved here². In 1952, the Archbishop of Salerno obtained permission to reopen the church to the public for religious purposes, provided the necessary repairs to the supporting structures were completed (Braca et al., 2000).

¹ As reported by State Archives (Salerno) in folder 1392, n. 10, titled: “Fabbricato dell’ex monastero di San Giorgio. Cessione al Comune”.

² As reported by Diocesan Archives (Salerno), in folder n. 30, titled: “Lavori di restauro della chiesa di San Giorgio”.

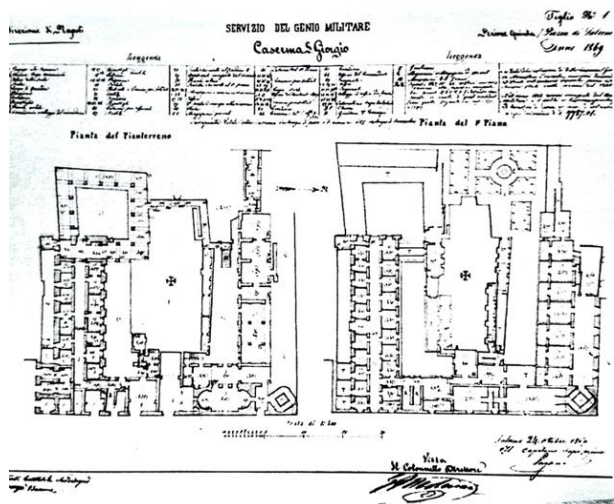


Fig. 4: Plan (ground and first floor) dated 1869 of San Giorgio site in Salerno kept at the "Istituto storico e di cultura dell'Arma del Genio" in Rome.

Restoration work, which officially began in 1957, included the reconstruction of the organ, the repair of the foundations and walls, and the renovation of the ventilation shaft and old floor (Bergamo, 1973). It was during this work that certain traces of the original structure and decorations that adorned the religious building were discovered.

After this long and demanding restoration work, completed in October 1958, the Church of San Giorgio was finally able to reopen to the public, regaining its place as one of the main historical, cultural, and artistic symbols of the city of Salerno.

The historical-architectural research on the church of the monastery of San Giorgio in Salerno has unfortunately not been able to benefit from vast scholarly literature. In particular, the investigation has suffered from a lack of iconographic sources testifying to the various construction phases of the religious building.

The documentation discovered in the various city and diocesan archives did not include images of the church, but only a few brief descriptions of works carried out at certain precise historical moments.

If we exclude a few degree dissertations (Cicatelli, 1968; Corsari, 1974) – somewhat dated and written by scholars with a purely humanistic background – few are the essays and studies that have critically analysed the entire historical-architectural evolution of this important church in Salerno, known almost essentially for its rich Baroque decorations.

If the contribution of the Neapolitan architect Sanfelice or the works of Solimena have been the

object of attention by some scholars (Natella, 1985), the reconstruction of the architectural interventions that took place during the Renaissance period, as well as during the decades of French occupation or the last phase of the 19th century, has been more complex. Even the documentation of the most recent work aimed at solving problems of rising dampness – due to the monastery's location near the sea – and the creation of the mechanical system that opens the accordion-like floor – allowing the medieval remains to be visualised – has been lost in the various institutional offices. The close collaboration and exchange of information with colleagues in the Drawing Department partly made up for and balanced this incomplete graphical information, thanks to the survey campaign and all those digital technologies that made it possible to visualise three-dimensionally the urban insertion, the spaces properly dedicated to worship and the architectural elements.

3. *Digital Surveying, through a multi-scalar approach for the full knowledge of the church*

Focusing on graphical representation aspects, the questions that came out of the historical research revealed a multiplicity and diversity of components of the church heritage on which to focus attention, requiring as many different operational approaches. It is known that cultural heritage may now be studied using a broad variety of methods and instruments that are widely accessible, covering surveying operations from macroscale to microscale (Fan et al., 2020; Antinozzi, Ronchi & Barba, 2020; Leserri & Rossi 2023). Consequently, considering the abundance of available methods, great consideration should go into selecting the appropriate survey methodology, taking into account the primary goal of the graphic documentation (Previato et al., 2022). In this sense, it was necessary to build an initial visual-infographic database functional to the full knowledge of the site and its context because, as previously noted, the Church of San Giorgio lacked graphic data.

To achieve a comprehensive understanding of the church, a multi-scale approach was implemented. This began with an examination of its context at a territorial scale, followed by the depiction of the monument at an architectural scale, and ultimately extended to the surveying of precious objects at a detailed scale. Using this method, the object was accurately measured after a straightforward initial observation. Since there

were no previous technical drawings or graphs, it became necessary to organise an initial information model. This model should be viewed as a foundational database that would support more in-depth thematic and disciplinary investigations in the future. It should also consider any additional contributions that might be needed in the future to protect the property. Furthermore, the significance of an immersive visual documentation as a tool for distribution that may help make the architecture understandable and accessible to both specialists and the public (Vaccaro, De Feo, & Ferreyra, 2021) is also not to be ignored.

Therefore, this interdisciplinary research experience is articulated around three distinct moments, allowing the church to be examined at different scales of detail:

- Territorial scale focuses on documenting the surrounding connective urban context.
- Architectural scale focuses on the morphology of the space and the interior decoration of the church.
- Detail scale focuses on specific valuable elements identified within the structure.

These three stages provide an organic structure to the entire experience, guiding those interested in the complete cognitive process of the Church of San Giorgio. Finally, the choice of the type of device to associate with each study phase was based on instrumental characteristics, including resolution, accuracy, acquisition time and the ability to capture photorealistic textures.

3.1 Territorial Scale

To capture the territorial scale comprehensively, the research team employed SLAM (Simultaneous Localization and Mapping) technology utilizing the GeoSLAM ZEB Horizon device. This approach afforded numerous advantages, particularly the rapid acquisition of large-scale data, facilitated by the Time of Flight (TOF) sensor integrated within the instrument. With the capability to measure up to 300,000 points per second in round-trip mode and a maximum range of 100 meters, this sensor ensured efficient and thorough data capture.

The device's efficacy in capturing intricate environmental geometries, including architectural nuances, while maintaining an acceptable noise level (within ± 3 cm) during data acquisition, was confirmed through meticulous placement of Ground Control Points (GCPs) along the survey route.

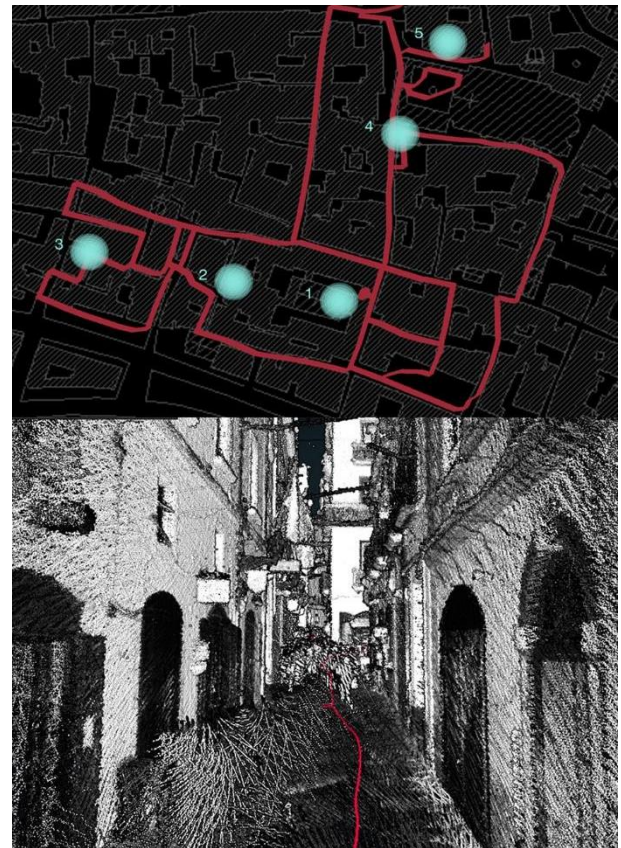


Fig. 5: Acquisition paths carried out with SLAM technology and identification of areas of interest: Church of San Giorgio (1); Area of the Former Benedictine Monastery (2); Area of the Royal Residence of the Langobards (3); Cathedral of Santa Maria degli Angeli, San Matteo and San Gregorio VII (4); Archdiocese of Salerno (5).

For a comprehensive depiction of the urban context, ten SLAM routes were accurately conducted (Fig. 5).

Encompassing an area of approximately 3 hectares, these routes demanded approximately 100 minutes for data acquisition. The resultant filtered point cloud comprised almost 800 million points.

Following data acquisition, the datasets were imported into GeoSLAM Connect software for automated processing employing the SLAM algorithm. Georeferencing of acquired patches was carefully executed by incorporating GCPs along the paths, ensuring a minimum of four points per individual cloud.

Subsequently, the patches underwent alignment and refinement using the iterative closest point (ICP) method. Further enhancement was achieved by closing the cloud alignment loop, yielding a root mean square (RMS) value of approximately 4 cm, thereby ensuring the proper accuracy in registration.

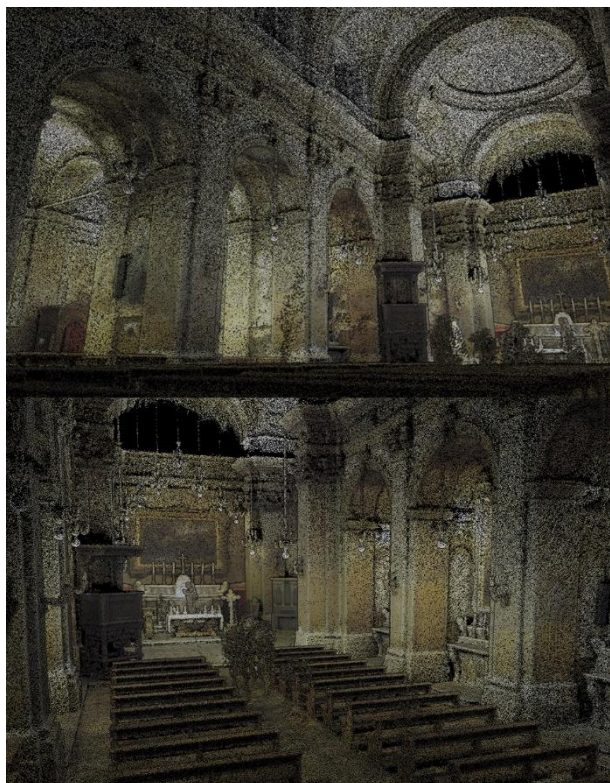


Fig. 6: Point cloud obtained as output from SLAM technology after alignment of the different loops.

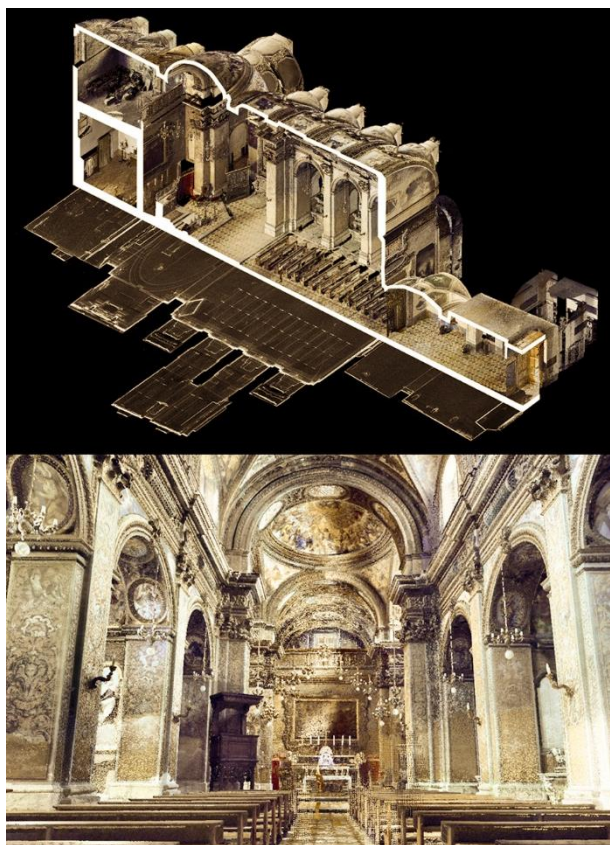


Fig. 7: Axonometric cross-section of the point cloud obtained as output from TLS technology.

This methodology facilitated comprehensive data acquisition and processing, laying a foundation for subsequent analyses and interpretations (Fig. 6).

3.2 Architectural Scale

For the representation on an architectural scale and the extraction of geometric graphics such as plans and sections, a TLS (Terrestrial Laser Scanning) survey campaign was conducted for the Church of San Giorgio using a Faro Focus3D x330. The chosen laser scanner, which uses phase difference measurement technology, offers a scanning range between 0.6 m and 330 m and an acquisition speed of up to 976,000 p/s. During the data acquisition phase, 21 stations were carried out to fill in the shadow cones caused by the limitations of the instrument's fields of view and/or the complexity of the geometry of the environment to be documented. Data processing was carried out in the proprietary Faro Scene software (version 2020), which is based on an algorithm for recording scans by minimising cloud-cloud distances through an ICP (Iterative Closest Point) algorithm. The generated point cloud (Fig. 7) is the basis for the subsequent texturing by close-range photogrammetry of the church interior.

The idea was to integrate diverse modelling tools and techniques, aware that using a single 3D surveying technique currently does not allow for the same efficiency and flexibility in terms of geometric precision, mobility, automatism, photorealism, and cheap prices in all working settings. Then, the acquisition of the frames took place using several Nikon cameras, including the D5600, D3200 and D800E, to apply a photorealistic texture from which significant perspective sections of the interior of the church could then be extracted.

The photographic acquisitions necessarily took place by means of controlled self-timer and camera on tripod, due to the low lighting inside the church.

The acquired frames were then divided by individual metric processing (sections or elevation) to minimise the amount of data to be processed on the single camera. Processing took place in Agisoft Metashape version 2.0 which, using the well-known workflow, produced the required orthophotos with maximum resolutions in the order of 1.5 mm/px, the basis for the subsequent vector graphic representation (Fig. 8).



Fig. 8: Vectorisation of orthophotos produced by close-range photogrammetry.

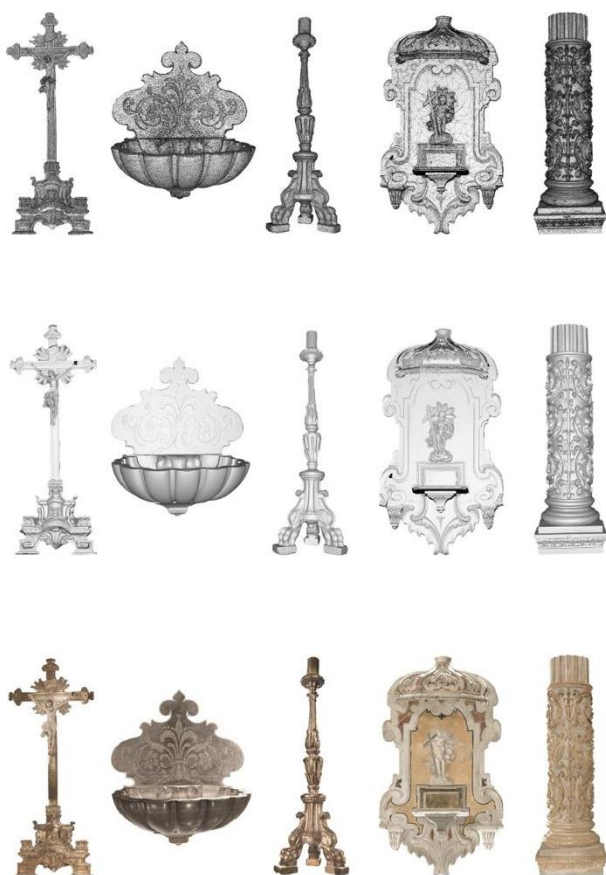


Fig. 9: Three-dimensional models obtained by structured light technology of the small precious objects stored in the church: in order from left, a crucifix, a holy water stoup, a candelabrum, a communion stand and an altar column.

3.3 Detail Scale

As stated, the historical research made it possible to recognise the most significant elements on which to focus attention and proceed with the surveys. These are not only furnishing elements, from candelabra to paintings for example, but also architectural ornaments and overall spaces transformed over the centuries. The communication of historical evidence is materialised in this way through detailed modelling that allows small portions of the environment to be appreciated at higher resolutions.

For the above purposes, the research team opted to utilize structured light laser scanning technology. Specific ornamental elements of varying sizes within the church, were identified for scanning (Fig. 9). These scans were conducted using the Artec Leo tool, a portable structured light scanner developed by Artec 3D. This tool offers the distinct advantage of providing real-time display of the object's 3D replica on its touch screen during scanning.

Structured light scanners operate on a principle akin to stereoscopic vision systems, wherein depth information is derived through triangulation.

However, in this context, the instrument projects a specialized pattern onto the object's surface to enhance measurement accuracy and expedite acquisition speed (Bell, Li & Zhang, 2016). Scans were meticulously executed within the optimal acquisition range of 0.40 meters to 1.20 meters, capturing single objects in one or more scans.

Subsequent data processing was conducted using the proprietary Artec Studio software, which generated a three-dimensional model in the form of a textured polygonal mesh (mesh). This model serves dual purposes, facilitating both geometric analysis and practical applications.

For instance, a potential extension of this digitization effort could involve creating a dedicated tactile pathway by 3D printing the scanned elements. These replicas serve various functions, including restoration, scholarly study, public display, or providing individuals with the opportunity to interact with architectural features without jeopardizing the integrity of the original structure.

The three-dimensional data acquired through diverse technologies, instrumentation, and detail scales were integrated into a unified multi-scale model. This model is adept at representing the urban environment, internal architectural features of the church, and select objects within it with

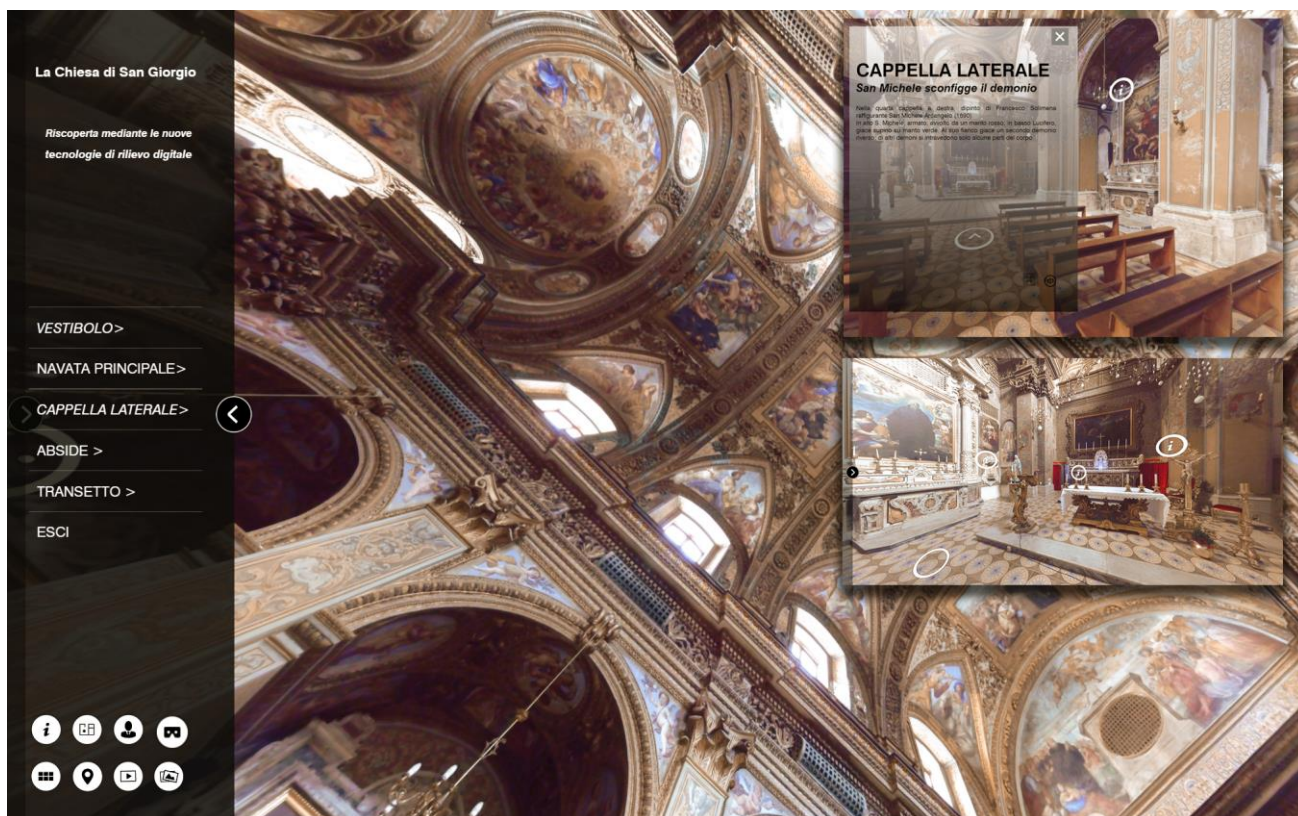


Fig. 10: Immersive visualisation of church views through the Virtual Tour desktop interface.

varying resolutions and accuracies, including millimetre-scale detail.

4. Valorisation of results

The interdisciplinary approach, combining various topographic techniques and advanced data processing programs, culminated in a comprehensive and meticulously crafted digital model of the Church of San Giorgio, establishing the groundwork for a thorough understanding and continual updating of its information repository.

The utilisation of these sophisticated survey methodologies, in conjunction with precise image acquisition and processing, facilitated the creation of an accurate, high-fidelity digital representation of the Church of San Giorgio. This endeavour significantly contributes to the preservation and appreciation of its architectural and artistic heritage.

As a visualisation surplus, the collected information was combined to create a virtual tour. This approach offers new opportunities to make architectural and artistic heritage accessible through a remote immersive mode of enjoyment. Users can now enjoy a virtual experience that takes them inside the church, allowing them to explore its spaces, interrogate the model accompanied by

archival information, observe artistic and architectural details, and appreciate its beauty without having to be physically present. Contoddo's study demonstrates once again that digitising architectural and artistic heritage opens new opportunities for preservation, education, and cultural dissemination, ensuring that the beauty and history of places like the church can be appreciated and shared by all, overcoming spatial barriers. However, the valorisation of the results required a further effort: there was a need for a space that would collect the material and at the same time be able to present it in an organic and effective manner. The possibility that we felt could satisfy this need was to use an immersive visualisation tool, the so-called "Virtual Tour" (VT), as an interactive container for the collection and presentation of the results (Fig. 10). This was also an expeditious procedure, as we had the possibility of linking together several 360-degree views previously generated during the survey (Fig. 11).

The idea was to use this new interactive graphic product to offer users the possibility of moving through an immersive environment (and between several stations), focusing their interest on freely chosen viewpoints. At the same time, the addition of



Fig. 11: Equirectangular projection of a 360-degree photographic acquisition used as input for the body of the Virtual Tour.

multimedia elements to the photographic environment, such as text, audio or images taken from the in-depth studies conducted, enriches the tool by configuring it as a real container of additional information. High-resolution panoramas, in this case, frame the housing of information content. In addition, an interactive experience-oriented approach leads to the design of a user-friendly product. For this reason, an interface was designed with a contextual menu that included intuitive navigation controls, the ability to switch between panoramas by previewing them, access to a floor plan for user orientation through a top-down view, a navigation help icon with instructions, and a button to switch to immersive viewing with VR glasses. Pop-up descriptions of the displayed space and the objects it contains have been associated with each individual station. Special attention has been given to bi-directional links (transitions between scenes) between adjacent views, to make the user's movement in neighbouring spaces more natural. Among the different access modes to navigate between sections, the following actions were ensured: (i) clicking on a point of interest within a top view or a plan; (ii) clicking on hotspots within the navigation of a panorama, with association to the name of the section that will be opened; (iii) selecting the scene from the pop-up context menu at the bottom.

The appearance of the VT in terms of image quality can enable the readability and distinguishability of details and materials, which, if clearly visible and zoomable, enrich the visual content with technical information. In this way, the

VT can also be understood as a visualiser to facilitate access to the analysis and interpretation of scientific data.

As it has been specifically declined in this application, the information base realised by VT constitutes a shareable, implementable, and extendable digitisation system for cataloguing, managing, studying, and enjoying the patrimony. The aims of VT, in perspective, can therefore go beyond the virtual visit: in line with the strategies of governance, valorisation and enjoyment of the patrimony, the use of this application is configured as a tool that also responds to the needs of social, intellectual, and economic sustainability.

5. Conclusions

The paper aimed to illustrate a cognitive approach proposed for the Church of San Giorgio in Salerno, but valid in general as a strategy for the documentation and valorisation of architectural heritage of historical interest. In particular, thanks to digitality and the opportunities associated with it, it was possible to experiment with forms of disseminating data and information based on an organic and engaging experiential approach. To enable successful communication that is understandable to a broad audience, much attention was paid to the graphic and visual component while maintaining the necessary level of accuracy, thoroughness, and scientific rigour of the material presented.

A virtual database that is derived from multidisciplinary investigations and translated into traditional and multimedia images and graphics has

actually been defined as a result of the development of virtual tours that the community can use to explore and learn about the Church of San Giorgio and the urban context in which it is located. This will enable visitors to explore and experience the Church of San Giorgio's beauty and spatiality in an immersive model³.

With the support of the Alfano I Foundation and the Curia, an exhibition presenting the findings of this experiment was organised and offered to the citizens of Salerno (Fig. 12).



Fig. 12: Exhibition “The Church of San Giorgio: rediscovered through new digital survey technologies” organised in October 2023.

Students, technicians, administrators, and locals all participated in the initiative, which gave the community a valuable chance to get more involved⁴. It also revealed to the community the existence of a place of celebration that many were unaware of and opened up new avenues for knowledge and cultural dissemination, which are essential for the valorisation and preservation of cultural heritage.

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The graphic outcomes are the result of the research experiences started during the course in Building Engineering-Architecture coordinated by C.F. and S.T. with the support of the Drawing lecturers in the various activities (life drawing, survey, 3D modelling, virtual tour processing).

Authorship of the Paper

All authors contributed to shape the research, analysis, and design of the manuscript. S.A. wrote “1.2 Dissemination strategies for cultural heritage” and “4. Valorisation of results”; C.F. wrote “3. Digital Surveying, through a multi-scalar approach for the full knowledge of the church”, “3.1 Territorial Scale” and “3.3 Detail Scale”; “3.2 Architectural Scale” was written jointly by C.F. and M.L; B.M. wrote “1. Visualising History: Graphic approaches in heritage preservation” and “1.1 Transdisciplinary and plural figures involved in the research”; S.T. wrote “2. Historical research, between lack of documentary sources and interdisciplinary work”. “5. Conclusions” was written jointly by B.M. and S.T. who were responsible for the general direction and planning of the project, actively carried out by C.F. All authors read and approved the final manuscript.

³ The Virtual Tour experience is available at: tour.centroictbc.unisa.it/sangiorgiotour (last accessed June 2024)

⁴ Watch the opening video of the event at the following link: youtube.com/watch?v=AeRSj_AB2Ek

REFERENCES

- Ansaldi, B. (2020). Misurare l'incommensurabile. Comunicare lo spazio prospettico dipinto a chi non può vedere. *Diségno*, 7, 177-188.
- Antinozzi, S., Ronchi, D., & Barba, S. (2020). Macro e micro fotogrammetria per la virtualizzazione della laminetta orfica (V-IV a.C.). In A. Arena, M. Arena, R.G. Brandolino, D. Colistra, G. Ginex, D. Mediati, S. Nucifora & P. Raffa (Eds.), *Connettere. Un disegno per annodare e tessere. Atti del 42° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione* (pp. 1538-1555). Milano, Italy: Franco Angeli.
- Bell, T., Li, B., & Zhang, S. (2016). Structured Light Techniques and Applications. In J.G. Webster (Ed.), *Wiley Encorsyclopedia of Electrical and Electronics Engineering* (pp. 1-24). Hoboken, USA: John Wiley & Sons.
- Benedetti, D. (2020). L'uso dei media da parte dei musei nell'era della pandemia Covid-19: criticità e potenzialità. *Media Education*, 11(2), 199-205.
- Bergamo, G. (1973). *Ricostruzioni delle chiese della città di Salerno e del suo Comune*. Battipaglia, Italy: Graf Sud.
- Braca, A., Pasca, M., & Carafa, R. (2000). *Il centro storico di Salerno: chiese, conventi, palazzi, musei e fontane pubbliche*. Viterbo, Italy: BetaGamma Editore.
- Brusaporci, S., Graziosi, F., Franchi, F., Maiezza, P., & Tata, a. (2021). Mixed Reality Experiences for the Historical Storytelling of Cultural Heritage. In C. Bolognesi & D. Villa (Eds.), *From Building Information Modelling to Mixed Reality* (pp. 33-46). Cham, Switzerland: Springer International Publishing.
- Cantone, G. (2003). *Campania barocca*. Milano, Italy: Jaka Book.
- Caputo, O. (1988). *Il Monastero Benedettino di San Giorgio in Salerno*. Salerno, Italy: Tipografia Europa.
- Cassese, L. (1950). *Pergamene del monastero benedettino di San Giorgio (1038-1698)*. Salerno, Italy: Tip. Beraglia, gest. Reggiani.
- Cicatelli, T. (1968). *La Chiesa di S. Giorgio in Salerno* [Dissertation, University of Salerno]. General Archive of the University of Salerno, Italy.
- Corsari, L. E. (1974). *L'Architettura barocca a Salerno* [Dissertation, University of Salerno]. General Archive of the University of Salerno, Italy. Retrieved from https://ariel.unisa.it/primo-explore/fulldisplay?docid=39usa_alma2151694840003316&context=L&vid=39USA_V1&lang=it_IT&search_scope=39USA_INST&adaptor=Local%20Search%20Engine&tab=local&query=any,contains,L%27architettura%20barocca%20a%20salerno&offset=0
- Crisci, G., & Campagna, A. (1962). *Salerno Sacra. Ricerche storiche*. Salerno, Italy: Edizioni della Curia.
- European Commission – EU (2022). *Indice dell'economia e della società digitale (DESI)*. Retrieved from <https://digital-strategy.ec.europa.eu/it/policies/desi>
- European Commission – EU (2024). *Digital cultural heritage*. Retrieved from <https://digital-strategy.ec.europa.eu/en/policies/cultural-heritage>
- European Commission – EU (2024). *Open Research Europe*. Retrieved from https://open-research-europe.ec.europa.eu/?utm_source=google&utm_medium=sem&utm_campaign=JSC35044&gad_source=1&gclid=CjwKCAjwzN-vBhAkEiwAYiO7oKujir673S2gYQuf1FW97edhuCBSj2o2x7QYucLd6CwIWAcq9lpUthoCS3oQAvD_BwE
- Fan, Y., Feng, Z., Shen, C., Khan, T.U., Mannan, A., Gao, X., Chen, P., & Saeed, S. (2020). A trunk-based SLAM backend for smartphones with online SLAM in large-scale forest inventories. *ISPRS Journal of Photogrammetry and Remote Sensing*, 162, 41-49.

- Florio, R. (2020). Disegno e misura per definire una ragione tra pensiero e progetto. *Diségno*, 7, 121-128.
- Galante, M. (1997). *Nuove Pergamene del Monastero femminile di S. Giorgio di Salerno*. Altavilla Silentina, Italy: Carlone Editore.
- Giordano, A., & Huffman, K.L. (2018). Advanced Technologies for Historical Cities Visualization. *DisegnareCon*, 11, 1-3.
- Leserri, M., & Rossi, G. (2023). The Digital Documentation of the Cultural Heritage Between Public Interest Versus Private Property. Survey and Research on the Immacolata Square in Martina Franca (Apulia, Italy). *SCIRES-IT - SCientific RESearch and Information Technology*, 13(2), 27-42.
- Jin, P., & Liu, Y. (2022). Fluid space: Digitisation of cultural heritage and its media dissemination. *Telematics and Informatics Reports*, 8, 1-10.
- Miglietta, A. (2017). Il museo accessibile: barriere, azioni e riflessioni. *Museologia Scientifica*, 11, 11-30.
- Ministero della Cultura – MiC (2023). *Piano nazionale di digitalizzazione del patrimonio culturale*. Retrieved from https://digitallibrary.cultura.gov.it/wp-content/uploads/2023/04/PND_V1_1_2023_v2.pdf
- Natella, P. (1985). Ferdinando Sanfelice e il Monastero di S. Giorgio a Salerno. *Napoli nobilissima*, XXIV, 12-15.
- Parrinello, S., Sanseverino, A., & Fu, H. (2023). HBIM modelling for the architectural valorisation via a maintenance digital eco-system. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVIII-M-2-2023, 1157-1164.
- Perone, M. (2003). *Salerno dell'Ottocento. Trasformazioni urbane dal decennio francese all'età umbertina*. Napoli, Italy: Arte Tipografica Editrice.
- Poulopoulos, V., & Wallace, M. (2022). Digital Technologies and the Role of Data in Cultural Heritage: The Past, the Present, and the Future. *Big Data and Cognitive Computing*, 1-19.
- Previato, C., Monego, M., Menin, A., & Achilli, V. (2022). A multi-scalar approach for the study of ancient architecture: Structure for Motion, laser scanning and direct survey of the Roman theatre of Nora (Cagliari, Sardinia). *Journal of Archaeological Science: Reports*, 43, 1-17.
- Vaccaro, M., De Feo, E., & Ferreyra, C. (2021). Gli arredi liturgici dell'abbazia di Fleury dall'età merovingia al XII secolo: Indagine storico-artistica e restituzioni digitali. *Hortus Artium Medievalium*, 27, 204-214.
- Villani, M. (2020). Ricerche sul cantiere storico della chiesa di San Giorgio a Salerno. In V. Russo & S. Pollone (Eds.), *Cupole murarie tra XV e XVI secolo. Programmi, saperi costruttivi e restauri attraverso la Campania* (pp. 186-188). Perugia, Italy: Altralinea Edizioni.