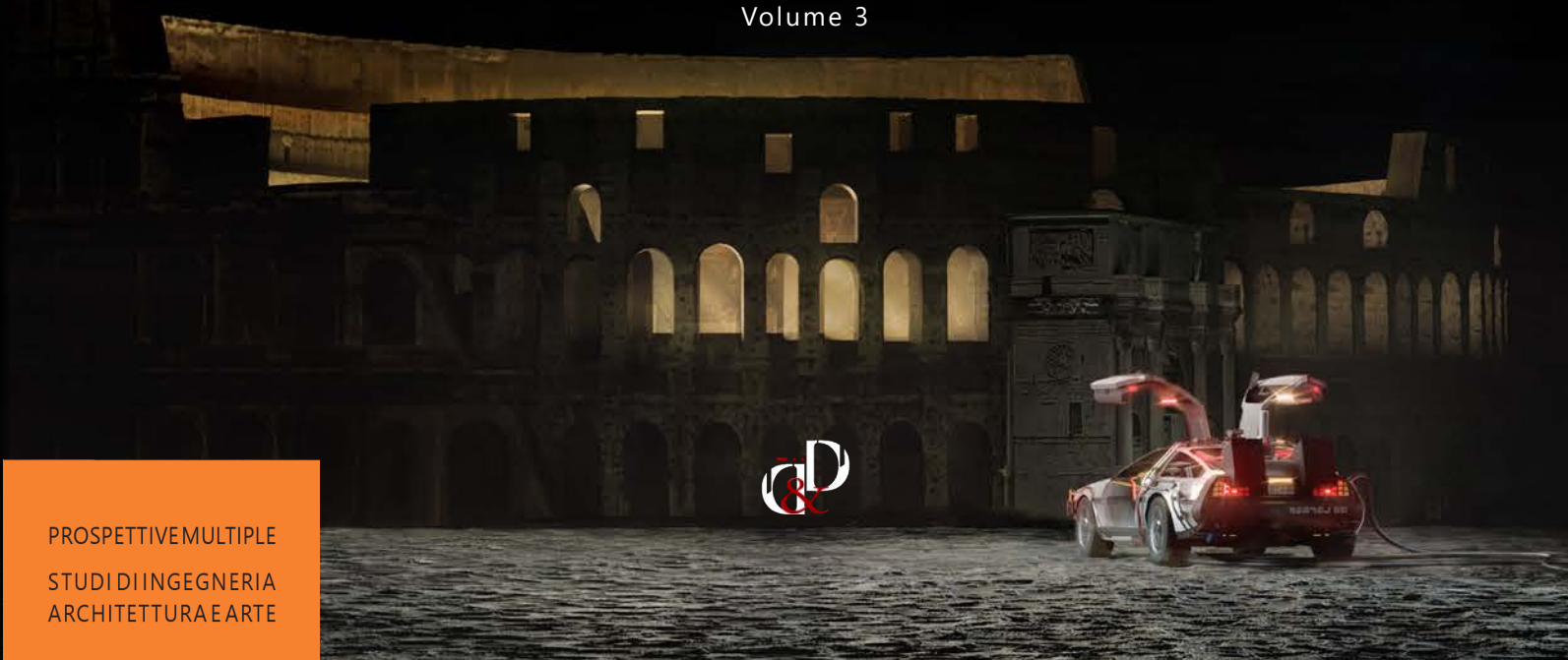
Laura Carlevaris, Graziano Mario Valenti

edited by

Digital & Documentation

Reading and Communicating Cultural Heritage

Volume 3



PROSPETTIVE MULTIPLE

STUDI DI INGEGNERIA
ARCHITETTURA E ARTE

Laura Carlevaris, Graziano Mario Valenti

edited by

Digital & Documentation

Reading and Communicating Cultural Heritage

Volume 3

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The volume consists of a collection of contributions from the seminar *Digital & Documentation. Reading and Communicating Cultural Heritage*, realised on online platform on December 4th, 2020. The event, organized by Department of History, Representation and Restoration of Architecture, Sapienza University of Rome, promotes the themes of digital modeling and virtual environments applied to the documentation of the tangible, intangible and natural Cultural Heritage. The event has provided the contribution of external experts who are engaged in the management and conservation of the most important Italian cultural assets.
The scientific responsible for the organization of the event is Prof. Graziano Mario Valenti, Sapienza University of Rome.

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The event *Digital & Documentation - 2020* has seen the participation of professors, researchers, scholars and private Institutions

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PART II

Laura Carlevaris
Graziano Mario Valenti

Sapienza University of Rome

Laura Carlevaris, Architect, Ph.D. in Survey and Representation of Architecture and the Environment, is Associate Professor in Sapienza University of Rome.
She is a member of the SDRA Dept. (Dept. of History, Representation and Conservation of Architecture) and a member of the Teaching Board of the Representation, History and Conservation Doctorate course of Sapienza.
Her studies and researchs mainly concern Descriptive Geometry, its methods, its foundamentals, history and teaching strategies, as well as representation and drawing of Architecture and the landscape and their thechniques.
She's currently teaching Architectural and Urban Survey in the Master degree in Architecture of Sapienza University of Rome and Drawing and Representation in the Landscape and Enviromental Planning and Design Bachelor's Degree of Tuscia University, in the DIBAF Department (Department for Innovation in Biological, Agro-food and Forest Systems).

Graziano M. Valenti, Associate Professor in the Dept. of History, Representation and Restoration of Architecture, Sapienza University of Rome, awarded the National Scientific Qualification as a Full Professor. His research activity focuses on the application of digital technologies to support design, construction, knowledge and communication of industrial and architectural products, with regard to Cultural Heritage, with the objective of anticipating future operational scenarios and solving current application problems. An expert in computer science, he's designed and implemented procedures and applications for sharing, integrating and representing data distributed over a geographic network. A specific topic in his research is the definition and representation of integrated and dynamic digital models that take on the role of both a container and a processing unit for heterogeneous information. From 2000 to the present, he's promoted and participated in numerous university research projects funded by Sapienza and MUR.

FOREWORD

Digital & Documentation 2020 focuses in its subtitle the verbs 'reading' and 'communicating' referred to Cultural Heritage. The choice of the two verbal lemmas, which seems natural, in fact, in relation to the objectives identified for the Study day, intends to highlight the centrality of Drawing interpreted in its broadest, modern, scientific and current meaning, within the complex process of Cultural Heritage valuing. A Drawing considered in the noblest and broadest meaning of the term, interpreted as a fundamental and main aid to the comprehension and communication of nature and artifacts belonging to real or imaginary space, which are expressed in the forms of tangible and intangible assets. A Drawing that is a privilege of humanity, through which humanity itself can express its Cultural Heritage and benefit from it. A Drawing that is embodied in a multiplicity of theories, tools and forms of expression, which are synergistically, seamlessly, integrated between analog and digital operations. Finally, a Drawing that stratifies over time, leaves its own traces and, as Franco Purini reminds us, is memory[1]: synchronic and diachronic documentation of the human existence and experience it makes manifest.

In this way, the terms 'digital' and 'documentation' also express their most notable meanings: the first, of memory; the second, of principal aid to the layering, integration, processing, representation and communication of documentation. Finally, with regard to the locution 'Cultural Heritage,' we would like to recall how vitally linked it is to the generalized dissemination of knowledge: it is evident, in fact, that communities are expected to preserve and protect the traces of their existence only in the case they know, understand and fully share the cultural value they represent. 'Valuing', then, means 'making accessible and 'transferring knowledge' to the widest and most diverse communities.

Although this publication was born and developed in the area of Drawing, it doesn't operate in an isolated scientific area. This is demonstrated by the fact that the event from which it originated is promoted by the Department that integrates the disciplines of History, Representation and Restoration of Architecture: a context of full contamination, the same contamination which is present in different forms in the other universities that contribute their scientific input to support the initiative.

From this perspective, the contributions here presented, devoting special attention to the considerable communicative, pervasive and persuasive potential of digital documentation of the cultural asset, interpreted as an augmented information support of the asset itself and a privileged way to get to its comprehension, are intended to accelerate the adoption and refinement of the best methodologies and practices of study. Thus, activities such as: documentary analysis; quantitative and qualitative knowledge investigations; technologies for data acquisition, normalization, cataloguing and interrogation; and modes of communication and interaction with digital information, with particular

regard for dissemination and popularization methodologies, considered vital communication processes for the enhancement of Cultural Heritage, fall within this context.
Taken together, these activities make it possible to operate on Cultural Heritage by organizing and integrating the processes of knowledge and communication which are characteristic of scientific research, orienting them toward a diverse audience in terms of nature and interests. Pathways of research, therefore, allowing both to disseminate results in different forms to a wide audience and to disseminate them in a scientific way to an audience composed with scholars. And it is precisely through these two priority communication channels, of raising awareness and attracting the interest of vast communities in the analyzed assets, that the main objective of the Study day is achieved in terms of dissemination of scientific culture and the transfer of knowledge: the valuing of the cultural asset.
The contributions of the authors here gathered and presented range from theoretical reflections, experimental activities, reports of experiences carried out or being conducted, and test operations of the best practices established to date.
The meeting we are presenting in these pages becomes the scene of debates, comparisons and demos of innovations, refinements, tests, methodologies, methodological experiments on the process of acquisition, critical and semantic analysis, dissemination and communication of Cultural Heritage.
In the three years of experimentation and evolution of Digital & Documentation Study days, which was intended to be itinerant, the founding committee, supported by scientific committee, has gradually matured a characteristic format, which for 2020 is divided into introductory reports by Cultural Heritage management actors and in-depth studies concerning original scientific activities produced by selected researchers, specially chosen for offering particular space to younger forces.
In the first group you'll find the valuable contributions of Erminia Sciacchitano, who was working into the offices of direct collaboration of the Minister of Cultural Heritage and Activities and Tourism, Dario Franceschini; Alfonsina Russo, Director of the Parco Archeologico del Colosseo (Colosseum Archaeological Park), accompanied by executives such as Federica Rinaldi, Head of the Flavian Amphitheater, and Stefano Borghini, Curator of digital enhancement of the Archaeological Park; and, finally, Dario Aureli, head of the Technical Office of the Palazzo Barberini Museum.
Alongside this first group, a number of young researchers whose work has been specially selected have been invited by the Digital & Documentation Technical Scientific Committee, in a context of constructive dialogue and comparison with the longer-standing scientific community.
All contributions are introduced by moderators who, with extreme expertise, have reconnected in an original and purposeful way the authors' researches.

Therefore, we hope, that this publication will represent a moment of knowledge sharing and updating, of significant importance for scientific progress. We hope as well that it may facilitate the development of new and young ideas, raising from the solid foundation of the established culture of more mature generations.
Indeed, we should not forget that the documentation of Cultural Heritage, today more than ever, has assumed a fundamental role in the collective global cultural horizon: natural phenomena and the dramatic and incomprehensible heinousnesses enacted in different historical and geographical settings and contexts put the preservation of Cultural heritage at risk on a daily basis and make it indispensable to continuously update the heritage of humanity in the different forms it may assume.

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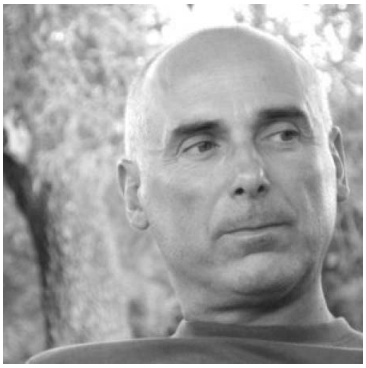
Note

1. Purini, F. (2019). *Drawing as theory.* In *Journal of Aesthetics* [Online], No. 71. <http://journals.openedition.org/estetica/5452> (last accessed May 13, 2023). DOI: https://doi.org/10.4000/estetica.5452.

PRESENTATIONS



Orazio Carpenzano

Sapienza University of Rome

Orazio Carpenzano is Full Professor of Design, Faculty of Architecture of Sapienza University of Rome.
Dean of the Faculty, he's been Director of the Department of Architecture and Design (2016- 2020). Coordinator of the Doctorate in Architecture Theories and Design and coordinator for the publishing activity of DiAP (Department of Architecture and Design), he directed the laboratory ArCo (Architecture and Contexts). Member of the Selection Committee in the Research Seminar of CiAUD. Former member of the scientific committee INARCH Lazio; he has directed the series *Print Doctorate*, *DiAP Print/ Progetti* and *DiAP Print/Theories*, published by Quodlibet.
He directed the Quasar Institute of Rome (post-diploma high school of design) in 2000-2007 and he's been president of the Culture Commission of the Faculty of Architecture of Sapienza.
Participating in design competitions he achieved awards and reports. His work has been exhibited at the Venice Biennale and in some collective exhibitions in Rome, Barcelona and Delft.

CENTRALITY OF THE PROJECT IN HERITAGE ENHANCEMENT

Today, the aid of digital technologies plays a central role, especially for those involved in the documentation of Cultural Heritage. Those who work in this field, with different specific roles, cannot disregard attention to the public domain and its needs – a concern that has grown considerably over time.
Today we have the need to make heritage what we might compare to a certainly attractive environment, but, above all, an environment capable of includinding the relationship that the consciousness of individuals needs to entertain with its past, with what it has inherited. It is clear that we are faced with a double dimension: one approach is cognitive in nature, the other is related to a projective dimension.
That's obvious: you cannot possibly communicate Cultural Heritage if you does not know it. But it is equally true that in order to give this heritage a perspective towards the future it is necessary to have its knowledge and appreciation shared. To achieve such a pupose it is necessary for the heritage to be actually narrated, and today a broad variety of tools are available along this process, and some of these tools make use of new technologies. By the means of new technologies we can initiate an important action aimed at reinventing the very images of heritage, so that, through this operation, we are able to enhance both the educational and communicative functions of the content transmitted.
It must never be forgotten that these operations always need to be based on a project, of course: we cannot preserve anything without a suitable project.As an aid to this project, new technologies assume a decisive role in the enhancement of heritage: they are not only able to bring out the existence of the asset, but they go so far as to expand the very possibility of experiencing it.
What we are talking about is a project that does not simply make it possible for a person to face the cultural asset we wish to preserve and conserve; a project, indeed, that allows the user to interact with the object focusing his or her attention, to completely explore its spatiality, to query about its cultural depth and the most suitable way to access a deeper level of knowledge.
People do not need anymore to play a passive spectator role: they need to be involved, stimulated to look for their own way through the path of knowledge.

Orazio Carpenzano

Carlo Bianchini

Sapienza University of Rome

Architect, Ph.D. in *Rilievo e Rappresentazione del Costruito*, Carlo Bianchini is Full Professor at Sapienza University of Rome, Department of History, Representation and Restoration of Architecture (DSDRA) of which has been Director from 2016 to 2022. He teaches Architectural Survey and Descriptive Geometry and has been involved in several national research projects and EU funded projects, often being author and scientific responsible.
Presently Editor in Chief of the scientific journal *Disegnare, Idee Immagini,* he authored more than 100 scientific works. His research main interests focus on Cultural Heritage, Survey, 3D Modelling, Virtual Museums, BIM and HBIM.
He partecipated as invited speaker in several conferences in Italy and abroad, often chairing specific sessions and as keynote speaker. He's also member of some cultural and scientific associations: Herimed, ASSIRCO (deputy president since 2011) and Unione Italiana per il Disegno (UID).
He is presently Deputy Rector of Sapienza University of Rome.

DIGITAL & DOCUMENTATION AS A TITLE

I have been intrigued by the *Digital & Documentation* conference since its very first edition.
My reaction has been certainly due to the scientific standing of the event, but also to its title.
After the so-called digital revolution, in fact, the sequence *Digital & Documentation* contains two of the most used (and maybe overused) terms connected to the Cultural Heritage. Differently from the general usage (Digital Documentation) the order of the words is though inverted being also 'complemented' by a conjunction that actually divides what is apparently an indissoluble bond.
I have always considered the disjunction of these terms (and of the tasks they refer to) quite interesting both on the theoretical and applicative side, although I do recognize that the activities connected with the Digital Documentation of the Cultural Heritage represent a consolidated and fruitful field of research and application.
My background reasoning is simple: at the same time, 'documentation' exceeds by far the 'digital' domain and the 'digital' domain exceeds by far 'documentation'. In other words and in my opinion, the rigid connection of these terms undermines the research potential in both domains.
This personal reading of *Digital & Documentation* is possibly one of the many reasons for the success of this traveling conference that celebrates this year its third edition. In this framework, I must mention that the conference, exactly for its trans-disciplinal character, was initially intended as one of the events of the 2021 Declinare Roma Forum, a biannual meeting organized by the Department of History, Representation and Restoration of Architecture of Sapienza University of Rome.
Unfortunately, the pandemic has determined the postponing of the Forum and thus this conference, at least from the Department standpoint, has become a 'stand alone' event instead of a coordinated one. Nevertheless, we are happy and proud as a Department of hosting this edition of *Digital & Documentation* both for its recalled character and for the quality of its presentations, the content of which, deliberately, I will neither discuss nor comment as others will be dealing with this task much better than me in the next pages.
Finally, I would like to thank the organizers, the speakers and all those who have in any way contributed to this successful event.

Carlo Bianchini

Emanuela Chiavoni

Sapienza University of Rome

Emanuela Chiavoni is Full Professor, ICAR/17-Drawing Sector, Faculty of Architecture of Sapienza University of Rome.
Coordinator of Ph.D. in History, Drawing and Restoration of Architecture, Sapienza University of Rome.
Member of the Editorial Staff of the magazine Drawing, Ideas, Images, Gangemi Editore, Rome.
Professor responsible for the Historical Archive of Drawings of the former Radaar Department at the Sapienza University School of Architecture in Rome, now Department of History, Drawing and Restoration of Architecture (DSDRA).
Member of the departmental team involved in the preparation, management and evaluation of several proposals for national and international research.
Main research topics in her scientific activity are the role of drawing in understanding the tangible and intangible architectural, archaeological and landscape heritage and the methodologies, tools and techniques for architectural survey.

D&D&DRAWING

The study day dedicated to *Digital & Documentation. Reading and Communicating Cultural Heritage* organized by prof. Graziano Mario Valenti to reflect on these contemporary issues hosted, also this year, in addition to professors and scholars, numerous Ph.D. students and students of the History, Design and Restoration of Architecture Doctorate Course as well as Assignees of the DiSDRA Department (Department of History, Drawing and Conservation) of Sapienza University of Rome.

From the experience gained during the coordination of the Ph.D. programme, I appreciate these studying moments as very special opportunities during the training experience of young students who have the opportunity of comparing ideas and methodological processes for research, interacting in different ways and actively participating within the interdisciplinary and international cultural debate.

During this year, with the aftermath of the COVID 19 pandemic, the three-year Ph.D. course was affected by the lack of direct relationships between students and the teaching staff; a physical, tactile absence and, above all, a distancing from direct contacts that weakened the stimuli and creative insights for research. By the means of digital instruments it was possible to continue communicating, working, having educational exchanges and not completely losing relationships with the teaching staff and colleagues themselves.

To the title of the study day I would like to add a third 'D', standing for 'Drawing' (*Digital & Documentation & Drawing, D&D&D*) to enhance the role of the latter in all knowledge processes both aimed at analyzing and designing Cultural Heritage. Drawing, in fact, is always subtended in every step related to digital and in all critical interpretation related to documentation.

In communicating Cultural Heritage, it is also essential to consider all that is inherent to intangible heritage "the practices, representations, expressions, as well as knowledge and skills (including tools, objects, artifacts, cultural spaces) that communities, groups and, in some cases, individuals recognize as part of their Cultural Heritage" and also, more specifically for our research area, the atmospheres and chromatic values that urban and natural landscapes, cities, and architecture evoke, also perceptually.

These are fundamental, intangible values to be preserved, improved and passed on to future generations as important memories and testimonies.

It was a pleasure to participate in the opening of this important study debate that suggested to all scholars and, above all, to young researchers, optimistic and dynamic research itineraries and articulated possibilities for cultural growth.

Emanuela Chiavoni

Francesca Fatta

Università *Mediterranea* di Reggio Calabria

Francesca Fatta, Architect and Ph.D., is Full Professor for Scientific Area ICAR/17-Drawing at the D'ArTe (Department of Architecture and the Environment) of the University *Mediterranea* of Reggio Calabria. She has been Dean of the same Faculty from 2007 to 2012 and she is coordinator of the Ph.D. course in Architecture of the D'ArTe.
Since 2019 she is President of UID (Unione Italiana per il Disegno), scientif society of the ICAR/17-Drawing area, and since the same year she is Editor-in-chief of the scientific journal *Disègno*, biannual online journal of UID.
Since the beginning of her scientific career she carries out research in the field of design, representation and communication of Architecture and the Environment and Cultural Heritage. She authored several books, papers and essays in Italy and abroad and participated to national and international meetings and conferences as a speaker or as keynote speaker, often chairing specific sessions.

DOCUMENTATION AS A MEMORY FOR COMMUNITIES

The initials *D&D* that characterize the name of this Study day bring to mind a background that belongs not only to Drawing but to the field we use to call 'Digital Humanities'. It is a subject that requires humanities and technological sciences to be brought together. In fact, we now generally agree that documentation includes drawing, surveying and modeling in its different meanings, ranging from the physical to the digital field, making use of all the most advanced technologies, but it is equally clear that the concept of documentation bases its strength on the idea of memory. It is precisely in this relationship that documentation becomes a fundamental hinge point, a junction that must hold together technology with the human sciences, history, with particular regard to those connections that configure the belonging of a community to its specific context.

I am referring to the vision of Corrado Alvaro, for example, who was perhaps the most prominent person in Calabria in taking up this concept of community and memory; but I am also thinking of the importance of digital documentation in the field of the great and terrible circumstances that have characterized some situations in our peninsula, such as the recent disastrous events, which suddenly erased a part of our memory.

Digitization can perfect systems of documentation ensuring that we do not lose the historical and cultural memory of our civilization. A need, a necessity that we have learned to be fundamental. One only has to think of what happened in Germany following the disasters of World War II to understand without astonishment how the community felt the need to rebuild their monuments immediately, when memory was still alive.

And so, digital documentation is precisely a need to make us sure that we create an archive, which can and should be as infinite as our ideas about Heritage, about the common good, are infinite.

Digital documentation is therefore a duty to a common asset, to live better, to have a more bright and participatory consciousness of the places in which we operate and live.

Francesca Fatta


KEY NOTES

Erminia Sciacchitano

Italian Ministry of Culture (MiC)

Erminia Sciacchitano serves in the Cabinet of the Italian Minister of Culture as Senior Advisor on Multilateral and EU Affairs, including the G20 Culture and the Euro-Mediterranean Naples Process, and is the National Contact Point of the New European Bauhaus.
She has extensive experience in European policies on culture, heritage, and landscape, with a focus on social values, creative economy, and regenerative management. Between 2014 and 2020 she contributed to the shaping of the EU policy on Cultural Heritage in general and to the European Year of Cultural Heritage 2018 as Chief Scientific Advisor in the European Commission, DG for Education and Culture. She previously held the position of Head of Unit for International Relations and Research in the Italian Ministry for Cultural Heritage.
She's an Architect and holds a Ph.D. in Historical Buildings Survey and a Master's Degree in European Studies and International Negotiations.

A CULTURAL HEART FOR EUROPE. CHALLENGES AND PERSPECTIVES

ERMINIA SCIACCHITANO

In recent years we have seen a radical shift in the approach to Cultural Heritage in Europe. I am a witness to how this has happened in the last six years since I directly contributed to this policy development in the European Commission at the Directorate-General for Education and Culture and as Scientific Advisor of the European Year of Cultural Heritage 2018. This 'revolution' has aligned at the European level the 'ethical' frameworks that are contained in the 'policy' documents adopted by the European Union institutions, primarily the European Commission, the Council of the European Union and the European Parliament and in the Cultural Conventions of the Council of Europe (fig. 1).

I can only cite two documents drawn up by the European Commission that mark key turning points in setting this conceptual framework: the Communication of the European Commission of July 2014[1]. *Towards an integrated approach to cultural heritage for Europe*, which brings to light the transversal dimension of Cultural Heritage policies, identifying in the integrated approach the tool to respond to the new pressing challenges that the sector is facing and to take full advantage of the support provided by existing resources. The second is the document drawn up by the Commission to capitalize on the results of the European Year of Cultural Heritage beyond 2018: the European Action Framework for Cultural Heritage[2], which is based on the principles of a holistic, integrated, participatory and evidence-based approach and articulates 60 concrete actions for 2019-2020 along with five key objectives: access and participation, sustainability, safeguarding, research and international cooperation.

This shift today leads us to look at Cultural Heritage in a new way, stimulating us to integrate the point of view of people and communities into our specialist approaches to the conservation and enhancement of Cultural Heritage. The result is more holistic: looking at Cultural Heritage from the point of view of people and inviting society to take care of it, breaks the barriers between the tangible and intangible and digital dimensions of Cultural Heritage

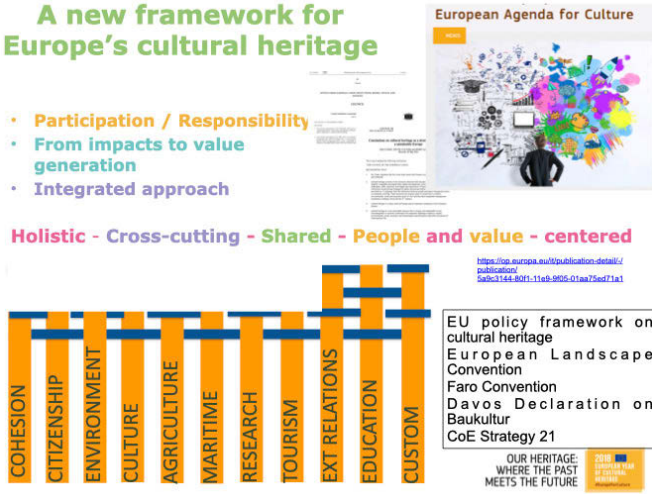


Fig. 1 - A new policy framework for Europe's Cultural Heritage.

and promotes its regeneration, including by stimulating the interactions between testimonies of the past and contemporary creativity.
Greater attention is also paid to the need to encourage participation in what must be understood as a common good, highlighting the fact that the transmission of our common cultural heritage to future generations is also an issue of common responsibility, which must involve not only the authority in charge of protection but also people and communities, the different administrations and levels of government and other hubs of knowledge and training, in particular, the Universities which are central to enable professionals in the sector to observe with new eyes heritage practices and play a new role in society.
This perspective, focused on people and communities, has gone from an approach that we could define as more defensive, which aimed to justify the 'why' of cultural investments by measuring their economic impact, to understanding that cultural investments are at the heart of processes of regeneration of territories and communities, which bring much greater benefits than economic ones and are more balanced in the four dimensions of sustainable development: environment, society, economy and cultural diversity. This also meant looking at Cultural Heritage differently, no longer a simple memory of the past, but a cultural, economic, environmental and social capital for Europe, a common good and key resource to reshape our future.

For this reason, an increasingly integrated approach has been promoted in Europe, working on all the cultural components present in all the different policies, from business to education, from research to cohesion policy, particularly evident at the European level. We will see that this integrated approach has also had consequences in the new financial framework of the European Union, where culture is more present than in the previous cycle.

The *Council of Europe Framework Convention on the value of Cultural Heritage* for society, also known as the *Faro Convention*, from the name of the Portuguese city where it was opened for signature in 2005, recently ratified by Italy, has played a key role in re-orienting the European Heritage policy framework (fig. 2). I have worked personally on the dossier of this *Convention* leading to its signature in 2013, and I consider it a cornerstone text for its clear innovative principles that have guided me in the work done in the Commission on European documents.
The *Faro Convention* identifies participation as the key element for investing in culture to produce benefits for all dimensions of sustainable development. The *Convention* also stresses the importance of Cultural Heritage as a factor that facilitates dialogue and mutual understanding between diverse cultures. To do so, it is necessary to understand that Cultural Heritage preserves not only the memory of joyful events but also of traumatic experiences that European peoples have lived in the past, from wars to catastrophes to commercial failures. This is necessary to be remembered

and continually elaborated on if we want to weave new balances of peace. The Faro Convention was born in the post-conflict years in Yugoslavia, in particular on the ashes of Stari Most, the 16th-century Ottoman bridge in the city of Mostar, in Bosnia and Herzegovina. The bridge has been destroyed on November 9, 1993, not so much as a military objective: a donkey back bridge, 4 meters wide, certainly did not constitute a threat to the passage of troops or heavy weapons. Instead, it represented the open door to dialogue between the two communities living on the two sides of the Neretva river, allowing them to talk for centuries, trade, and create new friendships and family ties; a door that the war wanted instead to close, in the attempt to divide and separate the two communities.
So today we are faced with a new vision, a new approach in this direction, and the demonstration is that the principles of the Faro Convention are identifiable in all policy documents of the European Union.

It is a great change, which can be summarized as 'from the object to the subjects' and which stimulates us to ask ourselves new questions, therefore not only "how" to preserve our cultural heritage and "according to what procedure" to do it, but also "why" and " for whom "to conserve and promote it (fig. 3).

The European Year of Cultural Heritage (2018) was an opportunity to fine-tune these new principles and to test the approaches and processes described in the European

Fig. 2 - The Faro Convention framework.

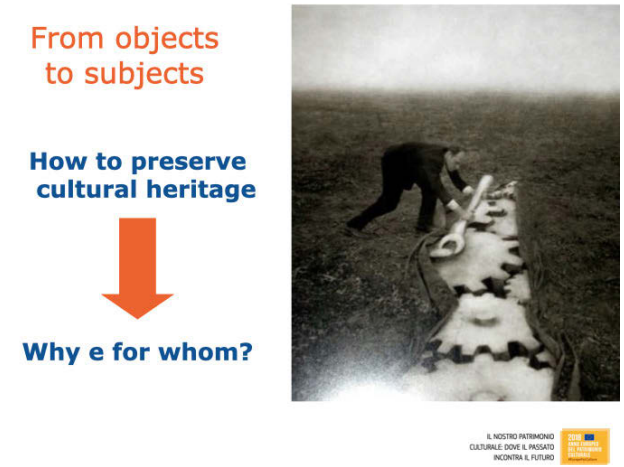
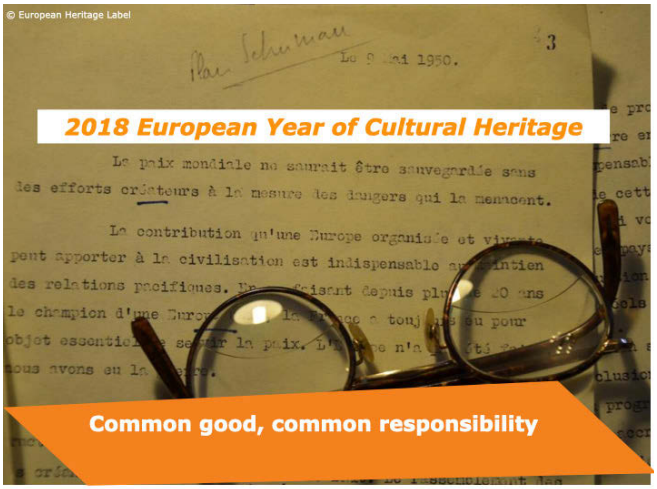


Fig. 3 - The Faro Convention, from objects to subjects.



Figs. 4, 5 - 2018: European Year of Cultural Heritage.

policy documents, which had been the subject of a long exchange and dialogue between the European Commission, other European institutions such as the European Parliament and the Council, the European Committee of the Regions and the European Social and Economic Committee and the various stakeholders, from representatives of National administrations to international organizations such as ICOM and ICOMOS to representatives of civil society such as Europa Nostra and the European Heritage Alliance 3.3.

The European Year of Cultural Heritage (figs. 4, 5) was also an opportunity to start working on increasing the capacity of heritage professionals who are called to review their processes. In particular, focusing on people and working in a cross-sectoral way implies a greater recourse to inter-disciplinarity. Consequently, 'participatory Governance' and 'management' are keys to activating this type of process.
Among other important issues, the extended accessibility to Cultural Heritage is crucial, to make sure that Cultural Heritage and culture are not the domain of a few, but who-

ever can benefit from them. All of this implies a large investment in skills, training and knowledge transfer.
Here I must say that my matrix of Italian training was probably decisive, compared to other countries that have more sectoral approaches to our issues, in giving me the certainty of convincing myself and persuading others to innovate well-established approaches, aware that a certainly more complex path was still manageable. Above all, the integrated approach is not a choice but rather a necessity, a need.
The experience of the European Year (fig. 6) has taught us that this integrated and participatory way of proceeding 'works'. Through the involvement of 15 Directorates-General of the European Commission, of 37 countries, of all the main international organizations, including the Council of Europe, Unesco, ICCROM, ICOMOS and ICOM, of civil society such as Europa Nostra and of the main networks, we have achieved results far beyond expectations. The results must be considered in terms of achieving concrete objectives: not only of mobilization but also of progress and a series of key dossiers such as those relating to the involvement of the European Civil Protection in emergencies for Cultural Heritage or the use of European Earth observation system *Copernicus*. I am also thinking of the great work done with research colleagues, or with colleagues who manage the *Erasmus* + and the e-Twinning program: these are all things that you will find in the next program such as Horizon Europe Cluster 2 dedicated to culture. Many opportunities have already been opened and concrete tangible results have been achieved by activating this example of 'collective intelligence'.
The last step of this conceptual work concerns the quality of the interventions carried out with European funds. This topic deserves some more information because I believe that this is the last phase of the conceptual work done in Europe (fig. 7).
For many years we have focused on the topic of quality as central to our role as experts. We who trained in this school had as our intrinsic goal that of producing quality results. Later we turned our attention to quality as a result of a process, developing targeted quality standard documents to provide requirements, specifications and guidelines to ensure that materials, products, processes, and services are fit for their purpose (i.e. ISO). We focused on the theme of open competition and transparency as a fundamental prerequisite for quality. Our new perspective introduces an additional element to the previous two, from the point of view of the actual benefits that our investments and actions generate: there can be no product that is defined in the round as a quality product if this does not create benefits for communities and the environment. An excellent, wonderful museum, perfectly set up, for example, cannot be said it achieves the expected results if it is not visited, experienced, known, if it does not become that hinge element, of transmission of knowledge, the fulcrum between the cognitive and the projective part, between past and future of the people of the territory concerned. For this reason, we have devel-

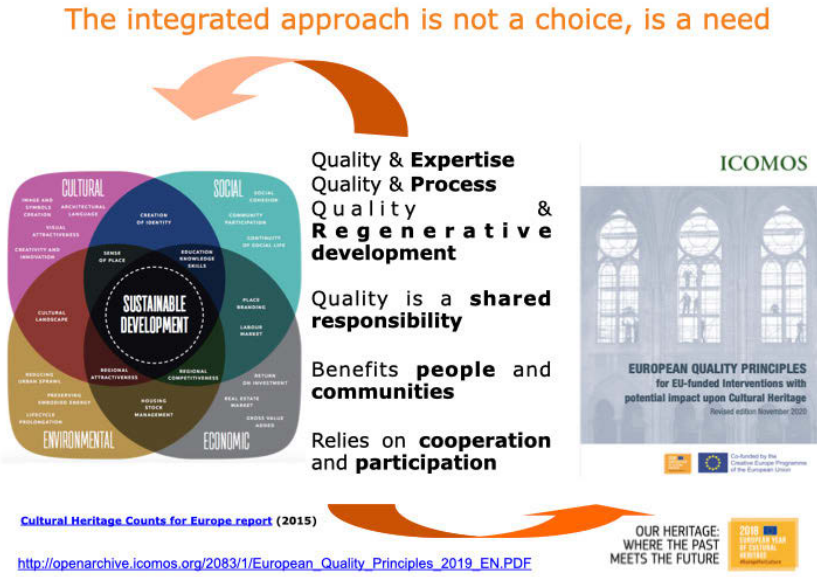


Fig. 6 - From principles to practice: the results of the European Year of Cultural Heritage.

Fig. 7 - A new approach to quality in EU investments in cultural heritage.

Fig. 8 - The European Framework for Action on Cultural Heritage.

oped with ICOMOS (International Council for Monuments and Sites) important guidelines, the *European Quality Principles* for interventions financed by the European Union with a potential impact on Cultural Heritage[3] (fig. 7), which is an important reference document at the European level to evaluate and reason on the issue of the quality of investments in Cultural Heritage, in particular in the context of structural funds but not only.
All this has been well defined in a document called the *European Framework for Action on Cultural Heritage 2019-2020*, mentioned at the beginning and which served as a bridge with the new European programming cycle thanks to the enhanced dialogue between the European Commission's colleagues (fig. 8).

The *Creative Europe Programme*, offers many opportunities, including in the digital field. The *Horizon Europe Programme*, the *Research and Innovation Programme* of the European Union, includes an entire cluster dedicated to *Culture, Creativity and Inclusive Society* which focuses on the challenges related to democratic governance, Cultural Hritage and the creative industry, as well as social and economic transformations with a budget of 2.281 billion euros. This will certainly be one of the European programmes (fig. 9) that will offer the community of researchers more opportunities to develop their work.
Having a dedicated cluster was not easy, but we succeeded thanks to the great work that has been carried out, a collective work, not only in requesting funds but above all in making people understand that culture offers an opportunity for regeneration and to build a renewed vision for Europe.
When we monitored the funding for culture and cultural heritage during the European Year of Cultural Heritage, we also discovered, to our great surprise, a real treasure: 90 million euros dedicated by the *Erasmus + Programme* to projects on culture and Cultural Heritage. So I would say that there are two really important sources that I invite you to go and explore: *Horizon Europe* and *Erasmus +*.
This is the past and these are the opportunities for the future. But I would also like to pay some attention to what

can be considered the challenges, nodes and problems with which it will be important, in my opinion, to grapple in the near future.
I am thinking of the *Faro Convention*, seen from the point of view of the digital community. If the centrality of the person and the communities have become the cornerstones of our reflection and considered all the essential keys to triggering cultural-based regeneration processes, giving rise to a season of experimentation and numerous projects, it is also true that the relations with the communities had to be abruptly terminated due to the pandemic.

Fig. 9 - Support for Cultural Heritage in the new programming cycle 2021-2027.

Fig. 10 - Culture-led regeneration of remote areas. John Gerrard, Mirror Pavillion, Corn Work, Galway 2020.

What I am showing you now is the case of Galway, European Capital of Culture 2020, which, as usual, has set its program on processes focused on communities and cultural regeneration.
The European Capitals of Culture open the territories to dialogue, where local creatives and traditional knowledge meet and "contaminate" with creativity and artistic creation that comes from other places.
The Capitals of Culture attract artists and talents and lead them to create in relation with local communities, helping them to regain awareness of the value of their cultural resources and to understand what may be the fundamental elements, identifying their past to build a new future project. Sometimes artists and creatives originate from these same places and thanks to these opportunities they return, after having made their professional growth path abroad, and play the role of mediators, capable of making distant realities talk to each other. This, for example, was at the heart of Matera 2019 European Capital of Culture.
In figure 10 you can see a very interesting work of art made in Galway: a mirrored cube whose three sides reflect the landscape and one side hosts an installation by a foreign artist.


Remote areas
Galway 2020 Gaillimh
European Capital of Culture
SHARE

This example represents the creative mix created by the European Capitals of Culture.
However, the pandemic has dramatically disrupted this process. How can I reach communities in situations like the ones we are experiencing? These processes work well in the 'physical environment', when we dialogue with the communities, triggering processes that take a long time but which pass through the human relationship. In my opinion, there is great potential to be explored in the digital world to stimulate culturally-based regeneration processes.
For example, intangible Cultural Heritage is strongly roed in communities. I recently visited San Sepolcro, where the famous Palio della Balestra is held every year since the XV century (fig. 11). In 2021 the Palio was officially cancelled due to the pandemic. The owner of the hotel where I was staying, told me that the Palio would be held anyway, for the local population, because the locals and the young flag-wavers, who had practiced all year round, could not resist without participating in this important event. I witnessed this interesting phenomenon: seeing the inhabitants of the city, behind closed doors, without any tourists, head quickly towards the place where that ritual was to be held. This episode reminds us how communities feel urged to renew constantly their commitment keeping alive these collective manifestations.

Long term commitment and sustainability

After all, one person's "landscape" may be another person's "tree, and all of these terms help make our objects discoverable online

How do you achieve that critical mass that allows a community to activate autonomously, without anyone acting as an 'activator'? This is an important issue, which includes anthropological skills and can only be addressed in the context of multidisciplinary teams.

Another interesting aspect concerns the digital dimension and the shared construction of meanings (fig. 12).
There are still a few experiments and among these a well-known one is that of the Brooklyn Museum, which began to explore the practice of Social tagging years ago, engaging local communities by asking people to attribute meanings to some paintings that were shared on the museum's website. Unfortunately, this experience was stopped when it was realized that in reality, the most active participants were 'usual suspects', some working in the same museum and that the objective of reaching out to the community had been fulfilled only in part. There are other interesting experiments, for example in Leuven, Belgium, where the City Record Office with the *Itinera Nova Project* engages volunteers in transcribing the digitized handwritten registers facilitating their online consultation.
Another interesting and important theme is dissonant heritage.
Let's look, for example, at what happened with Black Lives Matter, a worldwide anti-racism movement reacting to the brutal deaths of African Americans in the United States. In this context, in 2020 there have been a few attacks on statues representing people associated with slavery and racism. We can read this phenomenon as a reaction from these communities which were protesting against a slave past, no longer considered part of socially shared values, mirroring those meanings in the monuments in which they no longer recognize themselves. These attacks manifested themselves within a few

Contested heritage

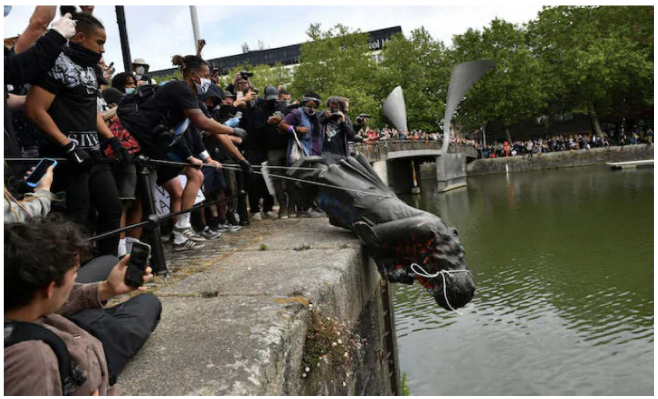


Fig. 11 - Sustainability and long-term commitment are rooted in the community of Sansepolcro.

Fig. 12 - Engaging communities in shared construction of meanings.

Fig. 13 - Dissonant Heritage.

days, leading to episodes like the one you see in the image (fig. 13). This is an important fact as it makes us understand both how much a community can be created through digital and how instinctively the association of heritage with identity and social values is close to people's hearts.
We, as cultural professionals, must engage more as mediators in these processes, and make understand that the value of the past is important, and contribute to its elaboration. Unfortunately, this has been developed mostly through digital platforms on which we do not move with the same agility.
During the European Year, we worked around the European dimension of cultural heritage. In figure 14 you see an image that comes from the House of European History, representing gas masks used in the Battle of Ypres. We invented gas masks in Europe because chemical wars were born here, in a continent of peoples
who have fought each other for centuries and which have only found peace in the last 60 years. This operation of looking at the past, of using Cultural Heritage to reveal some criticalities of today's society, turns out to be a valid help to help us to better face the challenges of the present, to understand how to resolve unresolved social issues.

There are, in this sense, other positive experiments of engaging digital heritage communities, for example, the huge mobilization around climate action facilitated by the *Climate Heritage Network* (fig. 15) which is using digital technology very well for in-depth meetings, knowledge building, creation of new tools, and understanding of what is being done in the various States, in particular about the role of culture in strategies of adaptation to climate change, on a global level.
A successful digital community was activated around the *COP26* in Glasgow in November 2021 and the *PreCOP26,* hosted in Milan.
This is a topic in which we need to become more protagonists because unfortunately, the world of climate science does not realize the fundamental role of culture in climate action and that culture has been a missing element up to now, crucial for changing our behaviors, for raising awareness on how to progress towards more sustainable lifestyles and how to increase our respect for the planet and the environment.

This thought is at the heart of the *New European Bauhaus* initiative, which was recently launched by the President of the European Commission Ursula von der Leyen, who calls on culture operators, architects, creatives and designers to mobilize society toward more eco-sustainable lifestyles (fig. 16).
To the theme of sustainability, I would add that of universal accessibility. The theme of 'access for all' should by now be something we have acquired and the two things must work together.
This is a topic that will be conducted at the European level, but there is an absolute need for Italy to make its contribution.

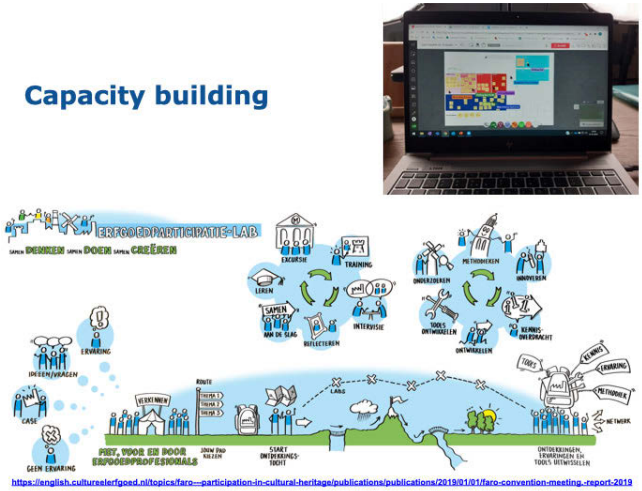
Fig. 14 - House of European History. The gas masks used in the Battle of Ypres.

Fig. 15 - Global mobilisation of heritage professionals for climate action – the Climate Heritage Network.

Fig. 16 - The New European Bauhaus.

Fig. 17 - Building the capacity of heritage professionals.

Fig. 18 - Nina Simon, Museum 2.0.



To do all this, new skills are needed. Here we see an example that comes from The Netherlands which has started a process to prepare the ground for the ratification of the *Faro Convention*, bringing together people who deal with Cultural Heritage and other experts on mediation who know better how to engage communities (fig. 17).
To do so, they organized a series of dedicated training courses, unfortunately slowed down by the pandemic since they had to be reviewed in a digital environment.
I believe that this experimentation is worth following closely, to understand what new models can be for the training of professionals on these issues but also in terms of Lifelong learning.

Conclusions

In conclusion of my speech, I would like to thank you for having organized this Seminar in the context of Digital & Documentation. From the profiles that have been shared and from the themes that researchers in your area are developing, it is clear that they are fully engaged in themes that look at the future (fig. 18). The digital is an enabling factor for mankind, it enriches us with new dimensions and perspectives and these dimensions need to be explored better. These concern the sphere of specialist knowledge but also, in some way, our role in building a better society. For this reason, it is important to open the way, to indicate new directions, and to create new opportunities for others to participate and innovate in their turn.
This is what this seminar is doing, and it is no small matter: it is by following exchange opportunities like this that it is possible to obtain new ideas and new perspectives for a better future.

Notes

1. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Towards an integrated approach to cultural heritage for Europe (COM / 2014/477 final): <https: // eurlex. europa.eu/legal-content/IT/TXT/?uri=CELEX%3A52014DC0477> (last accessed June 27 2022).

2. European Commission (2018), European Framework for Action on Cultural Heritage (SWD 2018 491 final): <https://op.europa. eu/it/publication-detail/-/publication/5a9c3144-80f1-11e9-9f05-01aa75ed71a1> (last accessed June 27 2022).

3. European Quality Principles for interventions financed by the European Union with a potential impact on Cultural >Heritage - Updated edition November 2020, ICOMOS, Paris: <https://www. icomos.org/en/about-icomos/committees/regional-activities- europe / 90984-quality-principles-new-version-available> (last accessed June 27 2022).

Alfonsina Russo

Italian Ministry of Culture (MiC)

Alfonsina Russo, archaeologist, Postgraduate Degree, Ph.D. in Classical archaeology, is currently Director of the Colosseum Archaeological Park and General Manager of the Ministry of Culture.
Her work focused on the enhancement and creation of museum networks and layouts and the organization of exhibitions in Italy and abroad (Strasbourg-Ancien Douane and European Parliament, Lyon, Montreal, Tunis, Bucharest, Thessaloniki, Louvre-Lens, Brussels, Tokyo), in collaboration with the Ministry of Foreign Affairs for the promotion of Italian culture.
She held lectures and seminars in major Italian universities, as well as in France, Switzerland and Germany and authored volumes and scientific contributions published in specialized Italian and European journals, dedicated primarily to cultural interchange among peoples of the ancient Mediterranean. She's editor of exhibition catalogs and scientific volumes. Throughout her activity, she devoted special attention to the involvement of local authorities and civil society and to the issue of physical and cultural accessibility of museums and archaeological areas.

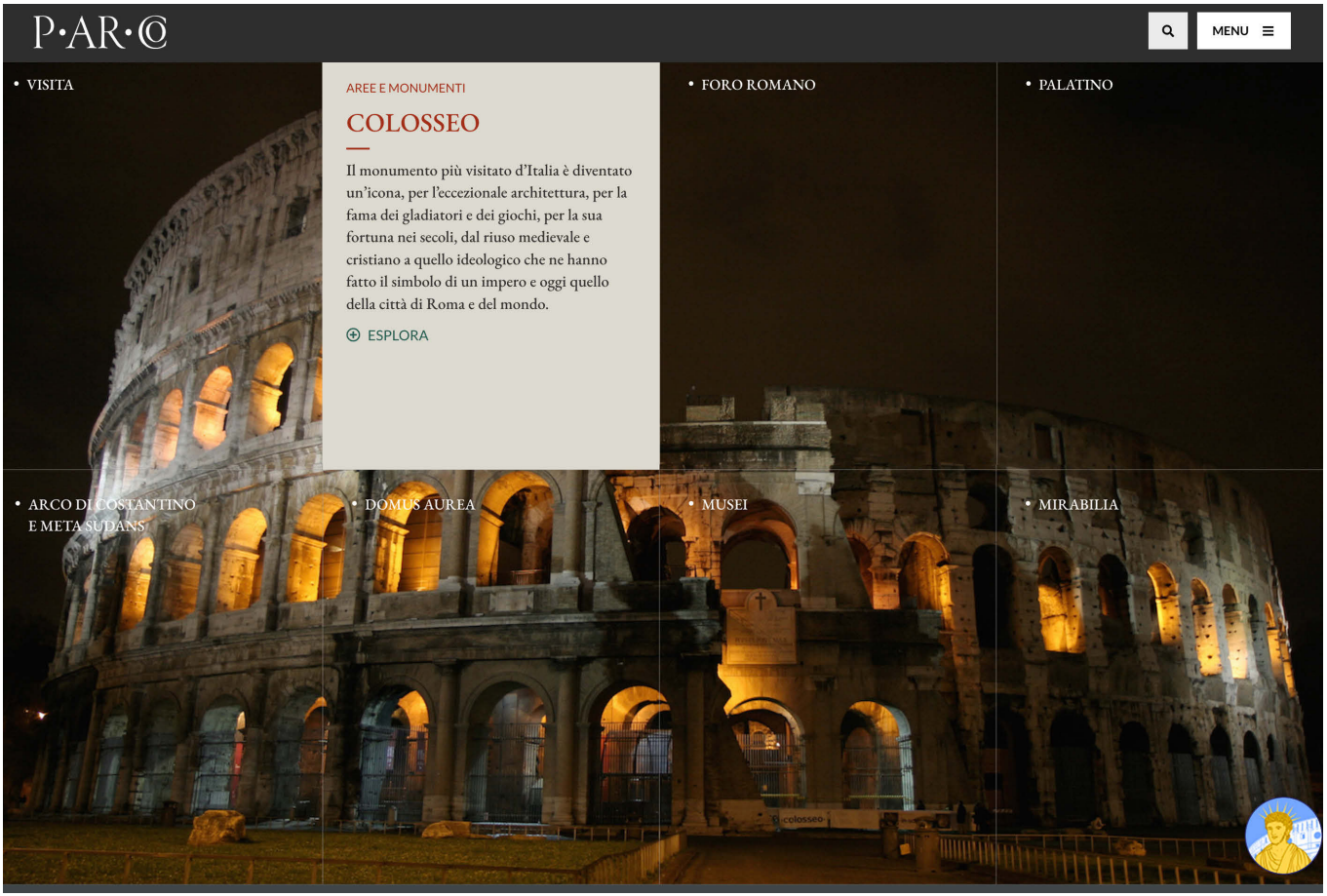
PUBLIC-FRIENDLY COMMUNICATION OF HERITAGE

Alfonsina Russo

In the context of the Colosseum Archaeological Park, memory digital preservation was aimed at better communicating identities and values characterized by uniqueness, of exceptionality. This is because we are precisely acting in a really special place.
Communicating these values in a way able to reach citizens and visitors constitutes one of the fundamental objectives of our strategic project, which aims to offer and disseminate knowledge in an increasingly conscious way.
In the aftermath of the pandemic, the prolonged closure of the Park to the public, as well as that of all Italian cultural sites, has led to the acceleration of a process of renewing communication and the relationship with the public that had already been initiated among the first activities undertaken following the establishment of the Colosseum Archaeological Park, which, we recall, was born in 2017.
The acceleration of this process has led to a rethinking of the relationship to be established with the public. During the period of restrictions imposed by Covid-19, in the impossibility of allowing the public to attend this extraordinary cultural site, as part of the new communication project promoted and coordinated by the Press Office of the MIBACT and titled *Io resto a casa* (*I stay at home)*, was initiated, the Colosseum Park, as was the case for all other cultural sites, enhanced its digital offerings, intended not as mere substitutes for on-site visits, but as extensions of not less engaging and immersive experiences.

In line with the Directives set out in 2019 by the General Directorate of Museums through its three-year plan for the digitization and digital innovation of museums, the Colosseum Archaeological Park established its own project aimed on improving its ability to make the museum institution a *forum*: an intended for sharing open space for visitors and scholars, based on strategies shared with other national and international museums and cultural institutions. The recent Protocol of Agreement signed with the British Museum in London, aimed at enhancing scientific and cultural collaboration between the two institutions, strengthening their ability in developing consultancies, creating networks of relationships and empowering the role of the museums themselves in the cultural life of nations and communities.
Therefore, we can say as follows: if in the past the site where the first meeting was held was a physical, real place, today this site is increasingly becoming a virtual and intangible space, created inside the same network to which people refer to find instructions concerning how and where it's possible to visit monuments and collections.
In the strategic and dynamic process of enlarging and diversifying the public and improving the overall conditions of enjoyment of the Archaeological Park, the exponential growth of digital users – imagined as those who aim to learn remotely about the history of the places, collections and activities – must therefore receive peculiar attention, aimed at providing the citizen as

Fig. 1 - Colosseum Archaeological Park site; <https://parcocolosseo.it/> (accessed February 3, 2023).



well as the visitor with the useful tools to be not only consumers but producers of their own cultural experience.

To achieve this goal in 2018 the website of the Coloseum Archaelogical Park was updated (<https://parcocolosseo.it/>; consulted on February 3, 2023) through an extension that now represents the fifth space in the system dedicated to the Park, going alongside the site of the Rome. These were then joined by the space dedicated to the Arch of Constantine and the *Meta Sudan*s.

It is therefore now possible to explore these extraordinary complexes online as well, through a series of thematic insights capable of providing 360-degree cultural contributions.

These are digital experiences that can be relaunched both on social media and on the Park's YouTube channel. Recurrently published informations concern the Archives and Collections of the Museum system of the Park, consisting of the Palatine Museum, the Colosseum Museum, the permanent exibition: *The Colosseum is told* and the *Museum of the Roman Forum*.

We also publish thematic itineraries that, in recent years, we have tried in every way to diversify and make more, and more attractive and, last but not least, our heritage care and conservation activities and restoration sites are presented through the portal.

On social media related to the Park, content aimed at reaching a specific public has also been included: under normal conditions, our Archaeological Park is visited mainly by an international audience; during the pandemic, our activity has focused on people living in Rome and surroundings and has particularly focused on information aimed at reaching users with specific needs, such as families and children. At the same time, while this change was taking place at the user level, our educational service has intensified the production of material that can be used at a distance, even offering new online games.

Therefore, the offer of new digital tools, capable of making the visit more and more aware and attractive, has benefited from the design and implementation of a new free App that will accompany the public on a discovery journey of our heritage in the sign of "design for all."

The new App, which offers texts and video clips in nine languages, videos with audio in Italian and English, video-guides in LIS language, audio-descriptions for non-sellers, and Italian and English content for children, will accompany the public on a visit to the Park designed for everyone.

Also in this new communicative direction, the Park and its monuments have been included in the international online platform *Google Art and Culture*, which allows high-resolution visualization of art works, virtual tours, and themes related to monuments and collections.

In the present, all of our communication activity is therefore focused precisely on a radical renewal, focused on attracting our diversified audience and satifying their demands and expectations.

Stefano Borghini

Italian Ministry of Culture (MiC)

Stefano Borghini is an Architectural Officer at Parco Archeologico del Colosseo, and has been working for Italian Ministry of Culture (MiC) 2012.
Ph.D. in History and Restoration of Architecture, he has taught Ancient and Medieval History of Architecture and Construction Techniques of Historical Buildings at Sapienza Università of Rome between 2007 and 2010.
He has been a specialist in the field of technology applied to Cultural Heritage for almost twenty years. He is currently the Technical Manager for the Roman Forum / Palatine, Domus Aurea, Santa Maria Antiqua and Palatine Museum. Manager for IT services, he has supervised all the main virtual enhancement projects realized in the Parco.

THE FOURTH LEVER: USES AND ADAPTATIONS OF DIGITAL, THROUGH ENHANCEMENT AND RESEARCH

Stefano Borghini

In her contribution to this volume, Federica Rinaldi identifies three different functions (or "levers") within the Cultural Heritage field, where digital tools are becoming an increasingly powerful presence: documentation about conservation themes, digital management of heritage protection activities, and online communication, aimed to enable participation of the general public[1]. All of us specialized operators working in this sector will have become accustomed to using these tools to carry out our daily activities and complete any required institutional processes.

There is however a fourth function of digital application, which in an almost Edmund Burke-like vision remains autonomous from the others, while being strictly connected to them. The "fourth lever" maintains a direct bond with communication but speaks to the visitors in direct contact with the Cultural Heritage site, rather than being aimed to the remote public. This truly emphasizes the site, by creating unique chemistry with the visitor. The cultural asset, an object sometimes difficult to understand for someone who is not a specialist, is now able to tell its story through the use of technology.

It could be said that the use of multimedia and digital enhancement is a "long lever", able to uplift an important mass: the general public. This is a fundamental component of our work, as it allows us to communicate the result of sometimes complex research to a wider audience (hoping it will keep growing wider). In order to achieve this result, it takes advantage of an effective key to unlock the visitor's deeper conscience: emotional and aesthetic involvement[2].

The application of this principle in the past twenty years has revolutionized the way museums and cultural sites are staged for the public.

In 1999 Claudio Tiberi, one of Italy's most important architecture historians of the 20th century, published a free brochure to hand out to his students in which he expressed a fundamental concept.

"In order to organize in a coherent system the multiple architectural works I talk about in my courses, I refer to one basic notion which I believe is enlightening: the relationship man establishes with his reality, which is the reason of the way he lives, understand, and enriches it with his work. It's a way of learning and existing and it creates a culture of place and time. There are many of these ways, creating a web of realizations and possibilities"[3].

The ways of life and interactions with reality found in the course of history are multiple, and so are the possibilities in which the present interacts with its past, its knowledge and its perception.

For millennia among the most ancient and ancestral cultures, history has been narrated in the form of epic poems, songs, or simple stories. This way of transmitting knowledge became a form of identity. It pulled on emotional strings and by doing so it consolidated the perception of the individual and collective conscience within a certain cultural period.

The vision of our past and the forms of communication in our museums have seen a significant change of direction in

the last twenty years. They went from a more aseptic, purely scientific, and classificatory form to the search for a "story telling" approach. As an example of this trend, the term "narrator" has replaced the word "guide" more and more frequently – a difference which is not only linguistic, but substantial. When narrating a story, there is an emotional involvement which makes the audience part of a "vibration". The phenomenon is not only intellectual but reaches deeper into the listener's emotional sphere. Emotions are a formidable vehicle for knowledge to reach through time and language barriers and re-build the very DNA of our culture without mediations. This process manifested itself in the form of a digital revolution of how museum displays and contents are staged, and storytelling has inevitably taken a central role[4].

The Parco Archeologico del Colosseo, continuing the work initiated by the ex-Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'area archeologica centrale di Roma, has adopted this revolution from the start. The Parco makes digital enhancement almost a distinctive trait of its activity – although of course the last two years of the pandemic inevitably limited its opportunities – and has proudly become an example of excellence in this area, studied both at a national and international level.

The installations hosted, both on a temporary and permanent basis, attempted to remain truthful to two main principles, which have constantly guided the planning: emotional involvement on one hand, language style simplification on the other. It should be noted however, that simplification here doesn't correspond to a mere banalization of the message or flattening of the content to make it more "contemporary". On the contrary, the aim is to translate the same content and communicate it in a way that can be understood by anyone, while maintaining the highest possible quality of the content itself.

In order to achieve such result, digital applications need to be used in different forms. The main guiding principle remains the knowledge about the monument and its aspects wanting to be highlighted. This will determine the choice of the best technology to be applied on each occasion. From this point of view, a digital enhancement project is not different from a restoration project. There is not – and there must not be – a standard approach to be taken in each situation. Enhancement, like restoration, is an arti-

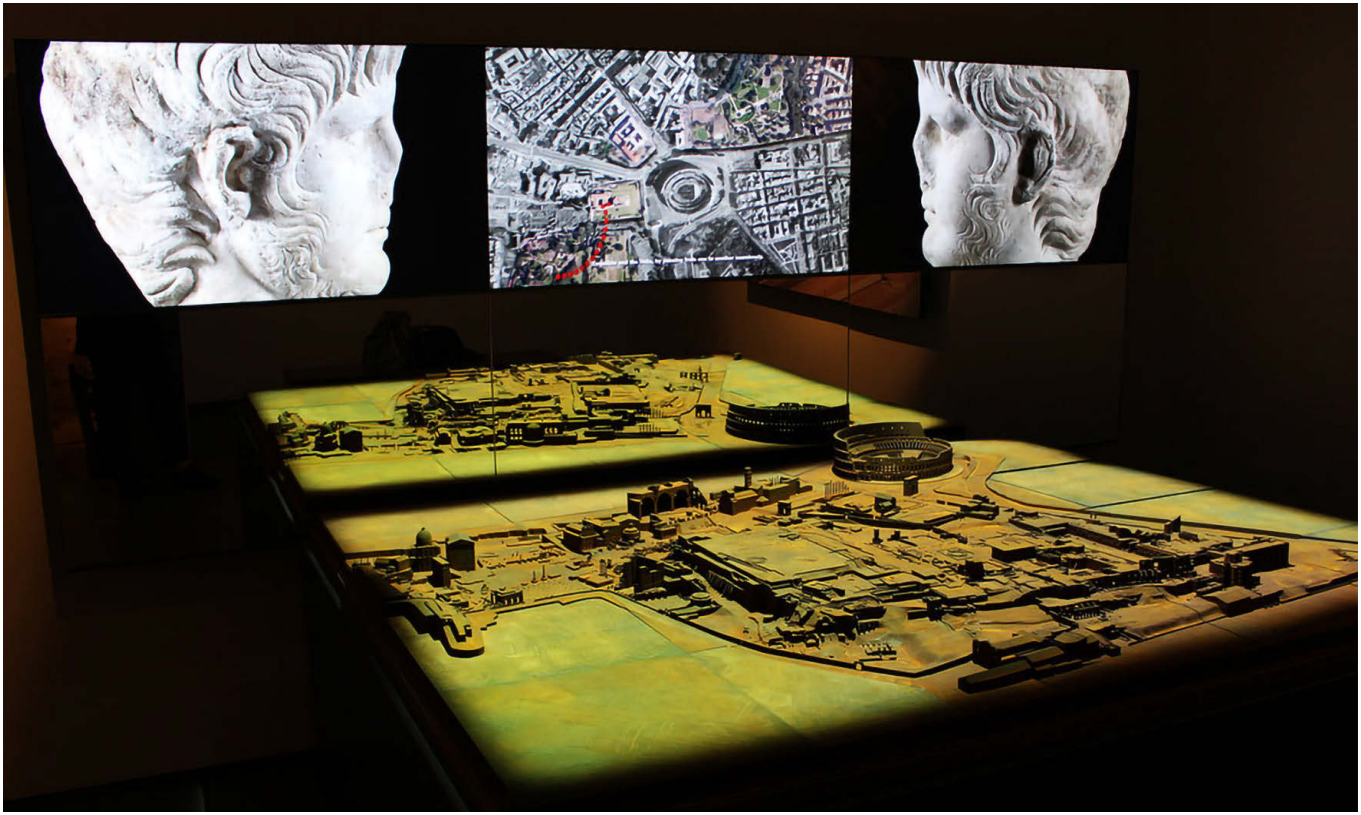


Fig. 1 - Palatine Museum. Plaster reconstruction model of the Romulus' huts. Katatexilux multimedia installation (photo by Katatexilux).

Fig. 2 - Palatine Museum. 3D printed model of the Palatine Hill as of today. Katatexilux multimedia installation (photo by Katatexilux).

Fig. 3 - Neronian cryptoporticus. Karamachina multimedia installation (photo by Karamachina).

Fig. 4 - Santa Maria Antiqua. Visual elaboration of the comparison between current state and virtual reconstruction (photo by Katatexilux).

Fig. 5 - Santa Maria Antiqua. Teodoto's Chapel, with immersive videomapping realized by Katatexilux (photo by Katatexilux).

sanal work (or even artistic if you will), where technology can never be the determining factor. The cultural object, with its values, materials and history will instead determine the best approach. Digital application will then be linked to the essence of the cultural object and only serve as a vehicle of expression of its nature.
In order to better exemplify this point, I will illustrate some of the applications the Parco has made available throughout its sites over the years.
A digital enhancement project was installed in the Palatine Museum in 2014 (then further upgraded in 2018). Here, the digital application serves as didactic support to the traditional visit, which becomes enhanced by informative windows, both visual and acoustic. Although not the most innovative, this was the first digital permanent installation in the area of the Roman Forum/Palatine.

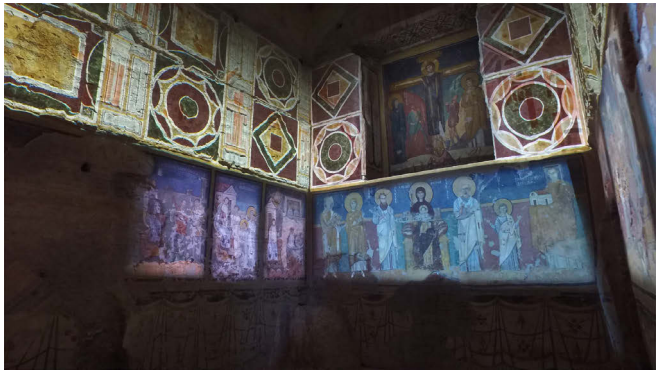


Fig. 6 - Horti Farnesiani on the Palatine. Ninfeo della Pioggia with multimedia installation realized by Katatexilux for the exhibition "Il Palatino e il suo giardino segreto" (photo by Katatexilux).

Fig. 7 - Horti Farnesiani on the Palatine. Ninfeo della Pioggia with multimedia installation realized by Katatexilux for the exhibition Il Palatino e il suo giardino segreto (photo by Katatexilux).

A system of virtual reconstructions inserted in traditional panels is supported by two interactive models: a plaster model (fig. 1) and a 3D printed model (fig. 2). These are used as a video projection screen, continued on the walls, which expands the visitors' experience[5].

Using an opposite concept instead, we came to the installation created for the Nero's *Cryptoporticus*. This consists of a large wall projection and proposes a visual art show based on the Palatine paintings, accompanied by music and sound. We call this an evocative projection as it is almost exclusively built on the emotional aspect, without any kind of storytelling[6] (fig. 3).

In Santa Maria Antiqua the 2016 temporary exhibition (made permanent in 2018), consists of videomapping projected on the walls, aimed to integrate the missings parts of the Medieval frescoes (fig. 4). These videos, only accompanied by short captions and music, focus the attention on the theme of virtual restoration.

The term restoration here is intended as integration with the use of light, and it indicates those cases where the aesthetic restoration of an object is achieved through an architectural projection on it[7] (fig. 5).

A similar installation was realized in 2018 for the exhibition *Il Palatino e il suo giardino segreto* in the *Ninfeo della Pioggia* of the *Horti Farnesiani* (fig. 6). Here some ample architectural projections enveloped the visitors in a grand visual tale[8] (fig. 7).

In both these examples the video mapping technique, in addition to enabling an emotional and extremely immer-

sive experience, moves towards the highest level of scientific communication, which is aimed to restore a pictorial or architectural image to its original integrity, something otherwise difficult to achieve.
The further two installations realized in 2018 in the *Domus Augusti* and *Domus Liviae* take the light restoration techniques experimented in Santa Maria Antiqua and insert them in the context of a visit fully guided by multimedia. In particular, the *Room of Perspective* in the *Domus Augusti* (fig. 8) and the *Tablinum* in the *Domus Liviae* (fig. 9) constitute the emotional climax of a circuit where virtual reconstruction, attentive lighting, music and narration take the visitor by hand through a fully multimedia guided experience[9].

The type of installation used in the palatine houses further evolved in a temporary installation created for the Colosseum night visits in the Summer of 2019. In this case the collaboration with a company specialized in the use of digital technologies from an artistic and almost scenographic point of view, produced a true multimedia show. In "Il sogno del gladiatore" a tale made of projections and shadows showed along the path of the visit ended with a film which was projected on the three sails of the arena, used as if they were a theatre curtain (fig. 10). The emotional crescendo created was comparable to the classical forms of a theatre play[10].
With the expression "restoration of light" (as opposed to the previously discussed restoration with light) we indicate an operation which can only be realized through virtual reality and is aimed to re-create the original light within an architectural monument. By doing so, we can also re-create the decorations, lost paintings, structural elements of a building which may have been damaged or altered by different lighting conditions or sun exposure.
At the beginning of 2017, a VR application was brought for the first time into the Parco sites, and particularly within the extraordinary space of the *Domus Aurea*. For the first time light, an integral part of the identity of the monument, was brought back within the model of its original architectures through the use of Oculus visors[11] (fig. 11).

Fig. 8 - Domus Augusti on the Palatine Hill. Room of Perspective with multimedia installation realized by Karmachina (photo by Karamachina).

Fig. 9 - Domus Liviae on the Palatine Hill. Tablinum with multimedia installation realized by Karmachina (photo by Karamachina).

I will leave to a more appropriate space the deeper theoretical reflections on how these applications can be used in the restoration field[12]; however, I will note how digital integration in these cases can be freely used to work with hypothetical reconstructions, without fear of permanently altering the archeological and the material data.

The installation created in 2019 for the Domus Transitoria took a similar approach (immersive experience through Oculus Go and wall projections)[13], while also taking advantage of the experience gained from the digital applications in the palatine houses to manage the interaction between artificial light and multimedia (fig. 12)[14].

Lastly, it is worth mentioning the realization of the first temporary digital exhibition in the Domus Aurea. The exhibition took place in the Octagonal Room and its surroundings, a space which doesn't allow traditional staging – due to its environmental conditions. The space lent itself well to the adoption of a fully virtual concept instead, enabling visitors to interact with large architectural projections accompanied by engaging and evocative sound effects (fig. 13).

Fig. 10 - Colosseum. Final film “Il sogno del gladiatore”, projected on the sails of the arena. Installation realized by Studio Azzurro (photo by Studio Azzurro).

Fig. 11 - Domus Aurea. Room 80, or the Golden Ceiling Room, staging of Oculus stations (photo by Roberto Galasso).

This form of interactive exhibit design, extremely immersive and capable of making a strong emotional impact on the visitor, sees multimedia technology as the absolute protagonist (evolving from its first limited use in the Palatine Museum 10 years ago). However, the design can also be turned off at regular intervals and almost disappear to allow the original architecture "to breathe" and show itself[15].

It will need to be further investigated how content communicated through digital applications can express, and in some measure preserve, different levels of reliability. While the emotional, evocative and aesthetic aspects made huge improvements over the last 20 years, the methodology linked to the validation and transparency of multimedia products seem to have stalled – crushed by operational difficulties.

Some of the experimental concepts currently being researched in the Parco include the use of 5G connectivity, which could enable the application of a method designed several years ago to be used for model validation and publishing of 'ideational sources'[16]. This could mean the separation of the "fourth lever" from the others, similarly to what was theorized by Burke for the powers of the state, could become no longer functional. The different expressions of digital could co-exist in products meant for enhancement, taking advantage of the multilayer nature of information technology. The ultimate goal is making virtual reality as transparent and honest as possible and transforming an educational context into one of research.

This theme could also be approached from a purely epistemological point of view. What do we mean by reality? What is real and what does it mean to represent reality? Can reality be represented in a unique, objective way?

According to Plato, the reality we perceive as pure is only a representation, an imperfect projection of a superior model: the world of Ideas. While this interpretation could seem forced, the paradox presented in the Myth of the Cave could actually be thought as the first description of Virtual Reality in an immersive environment[17]. The allegory describes a cave where some slaves are enchained and forced to only look at what is in front of them. The wall of the cave is used to project shadows of model statues representing all things of the world, and which are maneuvered by some other men hiding behind a wall. A fire at the entrance of the cave enables the projection of the shadows. The slaves, who cannot turn around and see the shadows of the man moving the statues, believe the shadows of the objects are the real form of things. It is not so incredible that a story – written some 2400 years ago – could be so apt to describing a modern issue. Although the technological methods vary, the problem remains the same: representation of reality.

The psychiatrist Paul Watzlawick states that the concept of reality is not unique and depends on the language we use

Fig. 12 - Domus Transitoria. Specus aestivus, staging of Oculus Go stations (photo by De Camillis – Fibbi).

Fig. 13 - Domus Aurea. Room 128 or the "Octagonal Room", installation realized for the exhibition Raffaello e la Domus Aurea. L'invenzione delle grottesche realized by Dotdotdot (photo by Livia Colopardi).

to interpret reality: "the most dangerous illusion is believing there is only one reality. In fact, many different versions of reality exist, some contradictory, but all resulting from communication and not being reflections of objective, eternal truths"[18].

Multiple realities can then exist. All are possible, equal, only resulting from different languages. And the only way to avoid the illusion of believing in one unique reality, according to the Austrian psychiatrist, is to work on communication.

So then, if the shadows in Plato's cave are virtual images, the men moving the statues are the digital modelers and the fire behind them is the technological application enabling the simulation, do we really need to give up the fire and approach reality purely from a scientific point of view? Or will it suffice to break the slaves' chains and guiding them to see what happens behind the wall?

Notes

* Translated from Italian by Ilaria Gaizo.

1. Rinaldi 2023.
2. Cfr. Borghini 2018.
3. Tiberi 1999, p. 7.
4. Cfr. latest Bonacini 2020 and respective bibliography.
5. <https://www.katatexilux.com/palatino; https://www.katatexilux.com/new-gallery-5> (last accessed October 31, 2021).
6. Corti, Aleotti 2018.
7. Borghini, D'Alessio 2021..
8. <https://www.katatexilux.com/new-gallery-4/kv05tx8csbybydf2s2sjz9ots4bbg1> (last accessed October 31, 2021).
9. Corti, Aleotti 2018; Borghini, De Camillis, Fibbi 2021, p. 84.
10. <https://www.studioazzurro.com/opere/colosseo-sogno-del-gladiatore/> (last accessed October 31, 2021).
11. Borghini, D'Alessio 2020; Borghini 2020, pp. 67-74.
12. *Ibidem*; Borghini, D'Alessio 2021, pp. 56-57.
13. Carlani 2019; Arrighi, Auci 2019.
14. Borghini, De Camillis, Fibbi 2021, p. 86.
15. Borghini 2020, pp. 74-78; Croci, Mandelli 2020.
16. Viscogliosi, Borghini, Carlani 2006.
17. Plato, *Republica*, 7.
18. Watzlawick 1976, p. 7.

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Italian Ministry of Culture (MiC)

Archaeological officer at the Ministry of Culture since 2010, Federica Rinaldi holds a scientific curriculum that includes degree, postgraduate school, Ph.D. and professional masters in *Management-Promotion-Technological Innovations in the Management of Cultural Heritage*. Since 2018 she's Head of the Communication Service of the Parco archeologico del Colosseo, where she devoted particular attention to online activities, with live broadcasts on social media, creation of Apps, videos and reportages. Since 2020 she's been Head of the Colosseum: in this role she has managed the difficult phase of the COVID-19 pandemic by organising new visit routes, designing new supports to the visit, with attention to accessibility, taking care of the scientific edition of important restorations and preparing the tender for the assignment of the 3D Geometric Survey of the Colosseum. Finally, she's particularly active in the application of technologies to the care and maintenance of Heritage, as the project of the Risk Assessment Map of Mosaic and Marble Surfaces managed by a Web GIS demontrated.

FROM THE 'MUSEUM TEMPLE' TO THE 'MUSEUM FORUM': DOCUMENTATION AND ENHANCEMENT AS CONCRETE DIGITAL EXPERIENCES IN THE CULTURAL SPHERE

Federica Rinaldi

Introduction

In 2020, in an attempt to return to normality after the COVID-19 pandemic, a selfie taken and circulated by the fashion blogger and influencer Chiara Ferragni in front of Botticelli's *Venus* at the Uffizi Gallery prompted detractors and supporters, eliciting both applause and criticism.

Chiara Ferragni's 'faults' at the Uffizi Gallery suddenly become the 'faults' of culture in the digital sphere, which associates the photo of the entrepreneur with the aesthetic canon of Venus, defining her as a "contemporary divinity in the social era"[1]: the photo triggered the followers of the Florentine museum, who considered this act[2] unacceptable and likely to cause the museum to lose its identity[3]. On the one hand, the Director Eike Schmidt, who is not afraid of criticism and continues to climb the social media ladder, explained how culture can become Italy's petroleum[4]; on the other hand, art historian and academic Tomaso Montanari, who strongly criticises the choice of the Uffizi5, drawing attention to the 'sanctity' of museums and the authenticity of works of art, thus sparking a lively debate on whether museums should maintain their 'aura of inaccessible temples' or, on the contrary, open themselves up to digital marketing with all the resulting consequences[6].

Without entering into the merits of the controversy that I wanted to raise only to enter immediately *in medias res,* we must certainly admit that now, in the Cultural Heritage sector, we have to co-exist with the digital world[7]: the long period of generalized closure of museums and cultural sites (as well as cinemas and theatres) imposed by the pandemic, has accelerated every objective[8], sometimes revealing inadequacies due to the absence of real digital plans on the part of institutions[9], sometimes even generating misunderstandings, but at the same time imposing the need to 'catch up'.

This fact, however, has not limited the typical contradictions of the human condition, divided between those who have 'snubbed' digital offers (and it should be investigated whether this is due to a rejection of the digital medium itself or to the inadequate quality of the products offered[10]), and those who have instead appreciated the possibility of concretely transforming themselves from passive consumers of the product into pro-sumers, exchanging and co-creating new cultural meanings and new knowledge about the arts. This is the case, among many others, of the contest 'Art looks like you', launched by the Ministry of Culture[11], in which directors and the public tried their hand at reproducing famous works of art with photos taken by themselves, as well as reproducing works of art with everyday objects.

On the one hand it is clear that in the period of emergency (or at least in the first wave of the emergency) digital tools were used by museums to ensure the continuity of previous operations and to continue to convey the same messages[12]; on the other hand, it is equally clear that they have a potential that

has yet to be intercepted and fully exploited [Cicerchia, Solima 2021]. This result emerged from the survey by the Osservatorio Innovazione Digitale nei beni e nelle attività culturali (Observatory on Digital Innovation in Cultural Heritage and Activities) of the Politecnico di Milano, conducted in 2020 and continued in 2021, which highlighted, despite the progressive improvement, the shortcomings in the digital innovation strategy, in the number and qualification of personnel dedicated to digital innovation, in the investment strategy (online ticketing, security and surveillance, cataloguing, digitisation)[13].

In this sense, the pandemic has confronted museum institutions with a 'crisis', in the original sense of the Greek word *κρίσις* and, to quote Christian Greco, in the sense of "choice, decision", which in turn derives from *κρίνω*, or "to distinguish, to judge" [Greco, Rossi, Della Torre 2020]. For the Museum, the time has come to choose 'what to do', i.e., whether to remain 'a temple and a guardian of heritage', or to become part of the evolutionary process, becoming 'a virtual arena' in which artists, visitors and cultural intermediaries can meet and interact in roles they have never experienced before.

The critical moment puts museums and cultural professionals in front of the possibility to choose which way to go, and above all how to go about it: the choice is divided between following the progressive emergence of digital tools adaptable to the management of Cultural Heritage, or instead accelerating on the path of designing new ones that are conceived from the beginning to meet the needs of curation, research and enhancement.

The digital/cultural heritage chain in the Parco archeologico del Colosseo

Let us then try to move from the theoretical to the practical level and define the digital Cultural Heritage chain within the Parco archeologico del Colosseo[14].

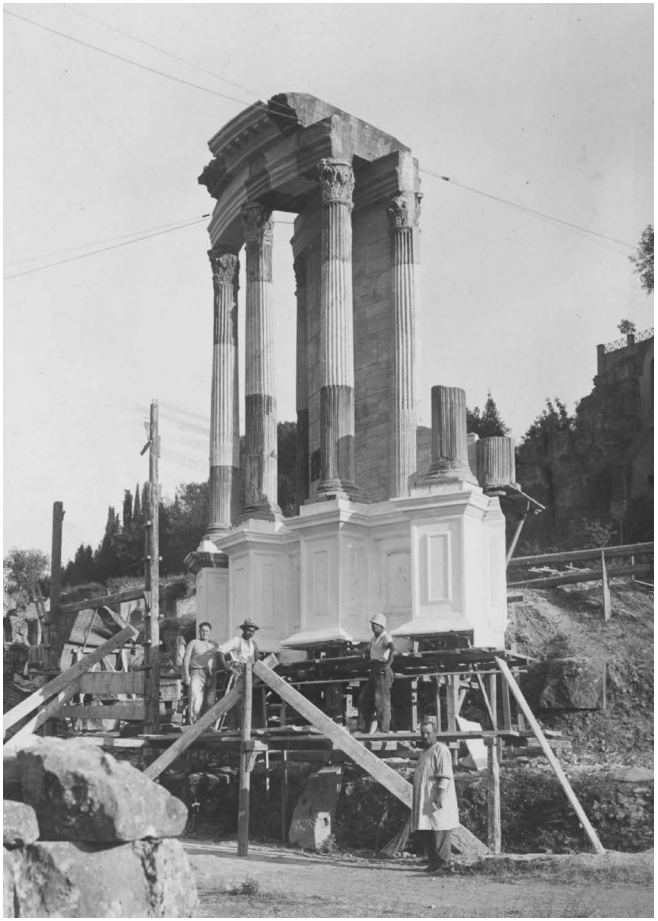
The starting point is that the first function of digital assets is to serve the most traditional mission of a museum, that is conservation, aimed at the production of documentation for archival purposes and diagnostics, and then at dissemination, fruition, and enhancement.

In a universe full of tangible and intangible cultural assets [Christillin, Greco 2021; earlier: Dal Pozzolo 2018], digital technology offers the potential for documentation, protection and management, and the construction of interpretation tools for physical and cultural accessibility, communication, use and enhancement with boundaries that are hard to imagine today [Dal Pozzolo 2018].

We begin with the documentation and, in a provocative way, try to go so far as to say that in reality "we are dwarfs on the shoulders of giants" who preceded us. Here are a few examples.

One of the most widespread digital documentation tools is undoubtedly 3D scanning, used to produce printed reproductions to use in data centres for conservation

Fig. 1 - Wooden model of the Colosseum by Carlo Lucangeli (late 18th century). ©Bruno Angeli for the Parco archeologico del Colosseo.



and memory. Rewinding the ribbon of history, we find illustrious examples, such as the wooden model of the Colosseum made by Carlo Lucangeli already at the end of the 18th century, even preceded by a cork model [Conti 2017] (fig. 1): the need to reproduce the architectural and structural complexity of the Colosseum in order to better understand its origin and function led, at that time, to the creation of a 1:60 scale model, in which real and 'virtual' were perfectly interpenetrated. Today, this extraordinary historical artefact provides an infinite resource of data that would otherwise have been lost, available to all, not only because it is on display in the Museum, but also because the progress of science and digital technology have enabled the Department of Sapienza University, which is hosting us at this conference, to create, manage and archive in 2016-2017 thousands of extremely high-resolution digital photos (350 gigapixel images, 100,000 images in support of Image Based Modeling and 210 laser scans), continuing in the chain of memory conservation with the application of more innovative technologies.

Following the line of time and approaching the century that preceded us, the case of the Aedes Vestae in the Roman Forum is worthy of attention: in the photographic documentation dating back to the 1930s and preserved in the archives of the Parco archeologico del Colosseo it is possible to trace the record of a 1:1 scale plaster model made to better study and understand the anastylosis of the Temple that today stands in front of the Forum

square[15] (fig. 2). Before the launch of the restoration works in 2019-2020, a cloud of points was obtained from the reconstruction of the Temple, which resulted in a 3D model (fig. 3) used both for the design of the interventions and to create an accessibility tool for blind people[16], as well as for sector studies on the behavioural responses to seismic waves [De Cesaris, forthcoming].

Finally, more recently, the Parco archeologico del Colosseo won the call for proposals *ICOM 2021 Musei High Tech*[17] that will lead, thanks to the integration with the experiences of Sòphia High Tech Srl in the aerospace and transport sector, to the realisation of an experimental project for the application of Industry 4.0 technologies, additive manufacturing and advanced 3D printing: for the realisation of the project the great inscription of the prefect of Rome Lampadius has been selected, which mentions the restoration works at the Colosseum following violent earthquakes in 443 AD. However, the relevant fact is that the inscription is clearly engraved on a reused block where the holes for the fixing of the metal letters that composed the inaugural inscription of the Colosseum by Emperor Titus are still clearly visible (fig. 4). The final product in scale, which requires a process of reverse engineering similar to

Fig. 2 - Aedes Vestae in the Roman Forum, plaster model in scale 1:1 (early 20th century). ©Photographic Archive of the Parco archeologico del Colosseo.

Fig. 3 - Aedes Vestae in the Roman Forum, 3D model, 2020. Nadir s.a.s. for the Parco archeologico del Colosseo.

Fig. 4 - Colosseum, inscription of the praefectus urbi Lampadius (443 AD). ©Bruno Angeli for the Parco archeologico del Colosseo

Fig. 5 - WebGIS Risk Assessment Map, mapping of the Pavement Units on the cartography of the Parco archeologico del Colosseo [Boldrighini et al., 2021].

Fig. 6 - WebGIS Risk Assessment Map, homepage [Boldrighini et al., 2021].

the one carried out for the reproduction of Michelangelo's David for Expo in Dubai, will combine different materials to restore the original inscription, becoming a scientific documentary object and a tool of accessibility for all.
Continuing with the narration of the digital Cultural Heritage chain and moving on to the topic of heritage protection and management, it is well established that digital technology allows for a more effective organization of work when it enables different specialists to be involved on a single 'platform', improving multidisciplinarity. Connectivity between information translates into interoperability, and this becomes possible within a digital environment specifically designed for this purpose. This is the case with databases and Geographical Information Systems, where integrated data management is the basis of the system, with the primary objective of representing a real operational tool to support complex decision-making processes and a targeted use of resources.
As Sole Project Manager I launched a pilot project for the extraordinary and ordinary maintenance of the vast heritage of mosaic and marble floor surfaces preserved in the Roman Forum and Palatine, conceiving and developing with a team of experts a webGIS, a Geographic Information System called "Risk assessment map of the mosaic and marble floor surfaces of the Roman Forum and Palatine" [Boldrighini et al. 2021] (figs. 5, 6). Starting from the survey and mapping of all the decorated floor surfaces (about 200) and from a check of the conservation conditions as well as of the critical levels caused by water stagnation, frost on the ground but also wear and tear caused by footsteps, an Information System was designed and set up to operate the integrated management of the following actions:
- archiving and management of historical, archaeological, and bibliographical information;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Via Celio Vibenna
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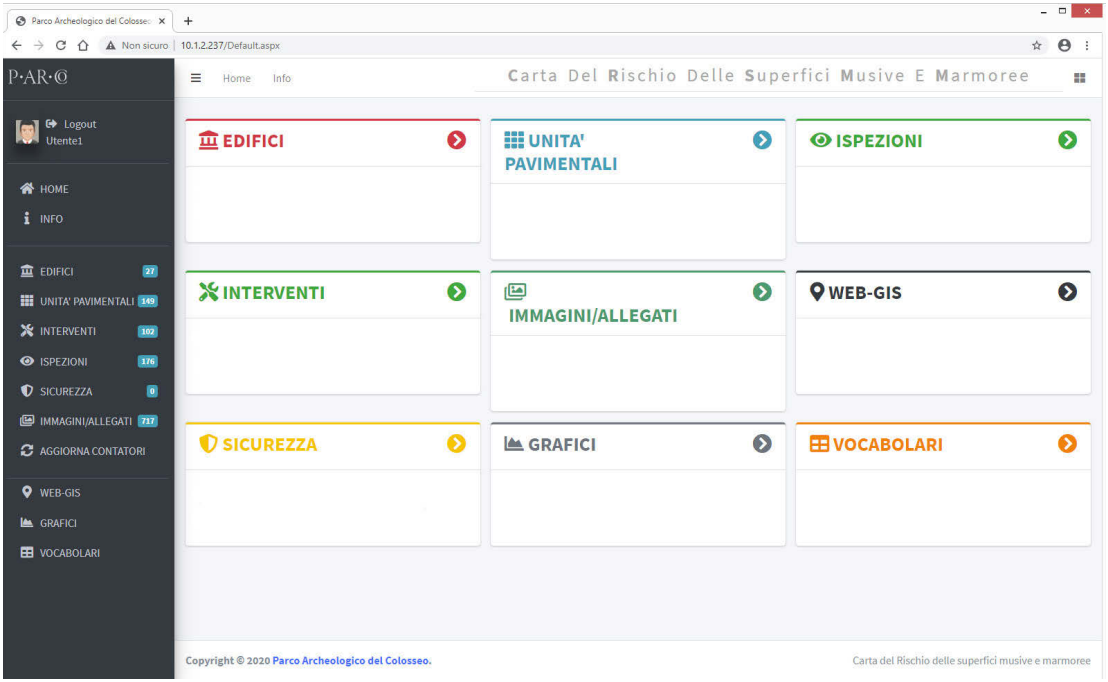
Carta del Rischio delle superfici musive e marmoree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Carta del Rischio delle superfici musive e marmoree

Fig. 7 - WebGIS Risk Assessment Map, interactive mapping <https://cdrweb.parcocolosseo.it> (last accessed May 19, 2023) .

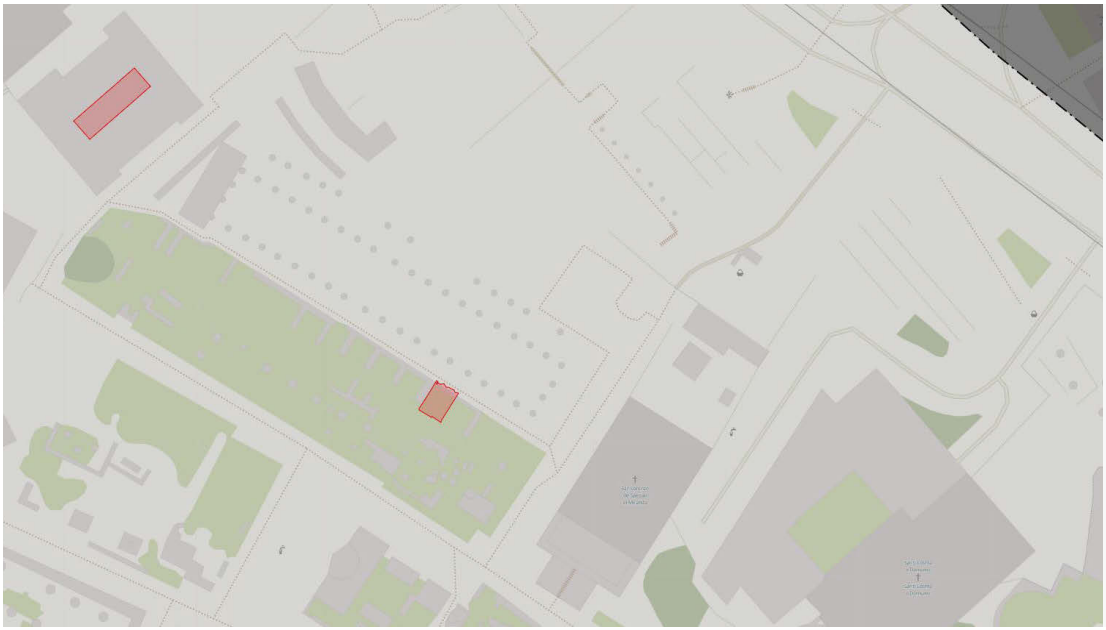
Fig. 8 - WebGIS Risk Assessment Map, interactive mapping. Detail of the polygons and the sectile legend of the Curia Iulia.

- translation on digital cartography of the floor surfaces and their perimeter;
- interaction with the cartographic data for an immediate visualization of the information through a WebGIS interface;
- input of data relating to daily inspections and conservation maintenance operations;
- monitoring of risk situations with request for immediate intervention;
- data management for the accounting of works.

A smart heritage approach presented at the We make future fair in Rimini in July 2021 and acquired among the outstanding digital projects of the Central Institute for the Digitisation of Heritage - Digital Library[18].

Recently, the entire project has been made available on the website <https://cdrweb.parcocolosseo.it> (last accessed May 19, 2023): using an interactive map, the polygons of the floors are visible and a gallery of images with a legend has been uploaded for each of them (figs. 7, 8).

When digital documentation is intertwined with knowledge, the resulting dialogue helps to break down the physical and cultural barriers that underpin the democratic value of our Cultural Heritage. In this sense, the Parco archeologico del Colosseo since 2018, the time of its establishment, has launched an intensive program of outreach, inclusiveness and participation aimed especially at the most vulnerable audiences, aligning itself with ministerial standards (PEBA) and showing – after reopening more than a year after the start of the pandemic – the ability to position itself as a factor of aggregation, dialogue, social well-being[19].



PAVIMENTO MARMOREO (OPUS SECTILE)

Il pavimento risale al rifacimento generale della Curia da parte dell'imperatore Diocleziano a seguito di un devastante incendio nel 283 d.C. Il disegno geometrico, redatto con marmi bianchi e policromi, mostra un sistema complesso di elementi vegetalizzati in porfido verde greco contenenti al loro interno un disco in porfido rosso, con foglioline a tre petali presso i quattro angoli. Negli anni Trenta del secolo scorso fu interamente rifatto e reintegrato, mantenendo l'assetto originario.

An example of this is the tactile map modelling, surely for blind people but also for all kinds of visitors, distributed in the 40 hectares of the Parco archeologico del Colosseo and implemented both by tactile 'digital contents', such as the three-dimensional reproductions of some findings of the museum collections of the Parco archeologico del Colosseo[20] (fig. 9), as well as multimedia contents which, by scanning a QR Code, refer to the brand new app *Y&Co*[21] designed for children, blind people and deaf people, as well as for anyone who wants to learn more about the history of the PArCo heritage through texts and videos.

So far, so good in terms of the perception of digital tools for Cultural Heritage, but when we move on to the third function, which is communication and enhancement, but

also and above all listening and participation, the never dormant debate is filled with the suspicion of a possible 'competition' between the digital and the original object, a suspicion that worries and agitates the cultural professional world and that, in a year like 2020, affected by the closure of the gates, has been one of the main topics of discussion. There is a fear that the availability of digital reproductions of very high-definition images, or even the possibility to visit museums remotely via virtual tours or similar, will replace the actual presence, the journey, the face-to-face experience, and not least the entrance ticket.

However, even if the debate does not fade away, statistics seem to say the opposite, that the more museums use the web, allowing remote access and querying, the more they succeed in attracting more numerous and diversified users by virtue of a global and contemporary attention to all potential audiences[22], acknowledging their inclinations, tastes, interests, building real cultural relationships.

From a psychological point of view, it is fundamental for every human being to be able to see for themselves if what is seen through the mediation of the Internet or other digital channels actually corresponds to reality, because beyond the virtual, it is the bodily experience, capable of making use of all five senses, that fully involves our sensitivity as people.

The Parco archeologico del Colosseo, having put the public at the centre of its strategy and mission, onsite and online, monitors month by month the growth rate and the social demography to check the place of origin, age, sex of its public, and through the social platforms @parcocolosseo it listens, engages, fosters the relationship by involving and taking care of its users, collecting requests, suggestions and data.

Moreover, to give an even more stringent contribution, at the moment of the reopening after the pandemic, the Fifth site of the PArCo has been established by right: in addition to the 4 assigned by Ministerial Decree n. 15 of January 12, 2017 (Colosseum, Domus Aurea, Roman Forum and Palatine), the opening of the Fifth site[23] has been formalised, unaffected by pandemics or trade union strikes (!) which consists of:

- website;
- social pages @parcocolosseo (Facebook, Instagram, Twitter, YouTube);
- podcast;
- digital publishing tools, such as video-guides and apps;
- online museum collections;
- docufilm (*Reopening Colosseum*) and reportages;
- newsletter.

A sort of digital department with multidisciplinary professionals[24] (archaeologists, social media managers, digital curators, video makers, curators of television products) that in three years of activity (2018-2021)

Fig. 9 - Palatine Museum. On the right, in the foreground, fictile antefix of a female head, original from the 6th century BC; in the background, tactile support with 3D printing of the fictile antefix; on the left, tactile drawing of the fictile antefix for the tactile guide Accarezzare la storia di Roma (Caressing the History of Rome).


Fig. E
1
antefissa a testa femminile policroma
polychrome female head antefix
2-3
teste di statua frontale fittile
– barbata
– dionisiaca (?)

has developed transversal products always conceived for their replicability both onsite and online and vice versa.

A 'transmedia' context – in which traditional storytelling has become digital[25] – that is also open to new interactive activities such as gamification[26], which is currently being developed, or original explorations that are always able to integrate knowledge and pleasure, in line with the current ICOM definition of Museum[27]: "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment".

Notes

* Translated from Italian by Francesca Pandolfi.

1. Isabella Borrelli (in Italian): <https://www.ninjamarketing.it/2020/07/23/chiara-ferragni-agli-uffizi/> (last accessed January 1 2022).

2. Giulia Ronchi (in Italian): <https://www.artribune.com/progettazione/new-media/2020/07/ferragni-uffizi-inaccettabile-follower-museo/> (last accessed January 1 2022).

3. Manlio Lilli (in Italian): <https://www.ilfattoquotidiano.it/2020/07/21/chiara-ferragni-agli-uffizi-per-avvicinare-i-giovani-il-rischio-e-di-perdere-la-propria-identita/5874879/> (last accessed January 1 2022).

4. Piera Anna Franini (in Italian): <https://forbes.it/2020/09/02/chiara-ferragni-agli-uffizi-direttore-schmidt-spiega-come-la-cultura-puo-diventare-il-petrolio-d-italia/> (last accessed January 1 2022).

5. Tomaso Montanari (in Italian): <https://altreconomia.it/uffizi-ferragni-larte-diventa-un-prodotto-da-consumare/> (last accessed January 1 2022).

6. Alessia Foglia (in Italian): <https://www.wai.life/marketing-museale2-0/> (last accessed January 1 2022).

7. On this topic, see Colombo 2020.

8. On the status quo of cultural offers by the main cultural institutions in the Lazio region in terms of digital and communication strategies at the time of COVID-19, see the recent volume edited by Toffoletti I. Chiusi per Covid, aperti per cultura. Musei e Comunicazione digitale. Bilancio e Prospettive. Roma: Gangemi editore, 2020.

9. For 2020, see the research conducted by the Osservatorio Innovazione Digitale nei beni e nelle attività culturali (Observatory

in Digital Innovation in Cultural Heritage and Activities) of the Politecnico di Milano which, out of 430 institutions analysed, revealed that only 51% are equipped with Wi-Fi and 23% have online ticketing. Marilena Pirrelli (in Italian): <https://www.ilsole24ore.com/art/nel-lockdown-musei-piu-social-ma-solo-su-quattro-ha-piano-digitale-ADYWzPT> (last accessed January 1 2022).

10. (In Italian) <https://www.finestresullarte.info/attualita/cultura-lockdown-visite-virtuali-flop> (last accessed January 1 2022).

11. (In Italian) <https://www.beniculturali.it/lartetisomiglia_online> (last accessed January 1 2022).

12. See, among many others, the experience of the Parco archeologico del Colosseo and of the Communication Service directed by the author, described in the contribution by Cella, Rinaldi 2021. The hashtag #iorestoacasa (#IStayHome) and the need to reach all the audiences that, not only in the contingency of the emergency but also at the end of it, would have preferred to 'stay at home' and continue to enjoy the beauties of history, led to the creation of the page <https://parcocolosseo.it/en/parco-online-2/> (last accessed January 1 2022) that collects all the digital experiences of the PArCo.

13. The Parco archeologico del Colosseo participated in both Observatories as a user and as a speaker.

141. See the contribution of Clini, Quattrini 2020, p. 157-177 from which I drew the graph of p. 171, fig. 1, to better visualize my reflection.

15. Following the restoration of the Aedes Vestae, the Parco archeologico del Colosseo has organized a one-day conference on June 9, 2021, of which the proceedings were published in 2022: on this subject see Russo, Giovanetti, Rinaldi 2022.

16. See infra.

17. <http://www.icom-italia.org/musei-high-tech-musei-lazio/> (last accessed January 1 2022).

18. (In Italian) <https://digitallibrary.cultura.gov.it/progetti/la-piattaforma-webgis-delle-superfici-pavimentali-musive-e-marmoree-del-parco-archeologico-del-colosseo/> (last accessed January 1 2022).

19. See the comprehensive contribution by Filetici, Rinaldi, Schiappelli 2021.

20. In addition to this tactile map tour, since September 2020 a tactile guide of the Palatine Museum has been added, with the evocative title Accarezzare la storia di Roma (Caressing the History of Rome), consisting of highly readable scientific texts (in Italian, English and Braille) and tactile drawings or reproductions: Rinaldi in Filetici, Rinaldi, Schiappelli 2021.

21. <https://parcocolosseo.it/en/yco-you-and-colosseo/> (last accessed January 1 2022).

22. On the publics of culture: Bollo 2019.

23. <https://parcocolosseo.it/en/parco-online-2/> (last accessed January 1 2022): Cella, Rinaldi 2021.

24. Federica Rinaldi (Head), Francesca Boldrighini, Elisa Cella, Giulia Giovanetti, Astrid D'Eredità, Andrea Schiappelli (PArCo), Francesca Pandolfi (translator, support to the Press Service and edition of monthly newsletters - coll. PArCo), periodically joined by interns and trainees.

25. On the topic: Bonacini 2020.

26. On the subject: Viola, Cassone 2017.

27. Updating in progress: <https://icom.museum/en/resources/standards-guidelines/museum-definition/> (last accessed January 1 2022).

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Dario Aureli

National Ancient Art Galleries

Dario Aureli, architect, Ph.D. in Sustainable Urban Development, was born in Rome in 1974.
After several years as a freelancer and visiting professor for the Faculty of Architecture of Roma Tre, in 2018 he became Head of the technical office of the National Ancient Art Galleries, where he is responsible for managing the planning of architectural works, the maintenance of the structures and the management of construction sites. During his career he collaborated on various research projects, publications and international design competitions.

MUSEUM. DIGITAL STRATEGIES IN THE MANAGEMENT OF COMPLEXITY

Dario Aureli

The role and proper definition of a museum has been debated for a long time, and will probably continue to be debated, as long as museums themselves exist.
In 2007, however, ICOM[1], a non-governmental organization founded in 1946 that establishes professional and ethical standards for museum activities, adopted an interesting and seemingly comprehensive definition of a museum: "A museum is a permanent, nonprofit institution at the service of society and its development, open to the public, that acquires, preserves, researches, communicates, and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study, and enjoyment." The same definition, moreover, is accepted and adopted entirely by Italian legislation in the MIBAC Ministerial Decree of 23 December 2014[2].
In this definition, which is now widely accepted, the museum is therefore defined through what are considered its essential functions, that is, the conservative (acquire, conserve), scientific (research, study, communication) and didactic (exhibition, education and entertainment) functions.
Again based on this definition, we can also say that running a museum means trying to fulfill these essential functions using the available elements, which, by abstraction, we could define as the three components proper to any type of museum, namely the building, the collection (the tangible and intangible evidence), and the visitors.
The interactions between these three components and the three essential functions identified above represent the intrinsic structure and very meaning of a museum. Therefore, it is not far-fetched to conceive of the museum as a true ecosystem, based on the relationships between what we have defined as the key elements, that is, the functions and components. Consequently, the possibility of managing a museum depends on the ability to control and intervene in the mechanisms of those interactions between functions and components.
Like an ecosystem, the museum is a complex system in constant search of balance between the elements involved. Managing the museum ecosystem, therefore, means trying to maintain this balance between components and functions. But doing this, today, turns out to be more and more complex, due to a series of historical contingencies that cannot be ignored and must instead be managed: the expansion of collections and deposits; the continuous exchange of artworks and information on an international level; the growing number of visitors from all over the world, even during the pandemic; the high performance expectations for the structures that host collections, exhibitions and visitors.
These and other factors are leading to an increasing complexity of the museum environment, which can only be addressed with a increasing cognitive and technological complexity, the only way to manage and reduce the entropy of a given system[3].
Today, the ordinary and extraordinary activities of those who have to manage a museum concern the control and management of an organism that we can define as constantly moving and changing, and requires adequate modes of intervention, possibly dynamic and potentially

instantaneous. It is therefore unthinkable that this management can be carried out with analogue methods and tools. The adoption of digital tools and methods of control represents the only available and sustainable resource. In the specific, the combination of digitization of data and documents and their use even remotely is to be considered as really useful for such management. This is the only way to effectively manage a complex system, to reduce this complexity, to control and intervene even in real time on the various components of the museum system.

Building on this awareness, museums are all gearing up to be able to respond to the need for greater cognitive and technological complexity by identifying a set of strategies and people with the skills to implement them. In the Gallerie Nazionali d'Arte Antica, three representatives have been identified, each responsible for one of the three general components mentioned at the beginning: an art historian to define strategies and activities related to the "collections" component; a promotion and communication expert for those related to the "visitors" component; an architect for the "building" component. These three people have the task of proposing objectives and developing strategies to achieve them, always acting in concert with each other, since all the components usually contribute simultaneously to the museum's ability to perform its essential functions.

Furthermore, it immediately became clear that, both from a strategic and operational point of view, the activation of partnerships with research institutes, universities and companies specialized in various sectors was a necessary

and indispensable condition for the realization of any strategy aimed at transforming the museum into an experimental laboratory of new applied technologies.
With this belief, several initiatives have been undertaken in recent years, following a path of progressive digitization of museum procedures, in which the collections and visitor components, often inextricably linked in their dynamics, have been the subject of the first experiments, even at low cost. A path undertaken with the specific objective of responding simultaneously to the different functions of conservation, science and education, accompanied by various technical partners.

The collections and visitors components

The digitization strategy has focused mainly on the creation of a digital archive of all the works in the collection, through the acquisition of HD images and a complete cataloguing. An effort made with the collaboration of the Hertziana Library, and which has continued uninterruptedly over the last three years. The goal was to create a tool for the integrated management of the collections through a web-based platform shared by all the different offices in charge of the protection, valorization, management and loan of the works of art.
In 2018, through a series of sponsorships, a project to enhance the Barberini and Corsini National Galleries called WeAct3 was carried out. It was a project to develop an idea of the Museum of the future, a museum in which technology supports creativity, with new proposals that

Fig. 1 - The visitors.

Fig. 2 - The building.

Fig. 3 - The collection.

Fig. 4 - Interaction between components.

allow to increase the link between people, artworks and the museum.

The proposals submitted for the project were presented in the Hackathon Barberini Corsini event, organized in collaboration with the business association CIVITA. Among these, the most representative idea to understand the logic of the initiative was the project of monitoring through geo-localized tags that allow to track visitors, and better understand their dynamics and visit preferences. It is no coincidence that the Galleries then activated a partnership with TecnoEI to participate in the SenSI project, a real-time visitor tracking system. Those who decide to participate are provided with a tag with which they are geolocated within certain rooms of the Gallery, specially equipped with Bluetooth systems. The system is designed for the management of visitor flows and the control of museum environments[4].

In 2019, due to an agreement signed with Haltadefinizione, a company specializing in digital technologies, three days of laboratory open to the public were held for a Gigapixel + 3D photogrammetric acquisition of La Fornarina di Raffaello. A very high resolution shot taken on the front, back and sides with a rendering of colors, tones, details, sharpness and lighting not otherwise achievable. The derived 3D model will also allow to map the object shape, brush strokes and cracks with an accuracy of the order of tens of microns, and will be used to monitor the conservation status of the work, but at the same time, it will allow initiatives for the dissemination and enhancement of Raphael's image.

These are examples of a process of progressive digitization, in which the component of the collections and that of the visitors are shown to be closely connected, and which is allowing the Galleries to carry out their conservative and scientific function, while at the same time providing essential opportunities and materials to improve their educational and recreational role for the public. Examples of this are the augmented reality proposals made available in the multimedia table of Palazzo Barberini and the tablets for the virtual guided tour of the Corsini Gallery, which use data from the digitization of the collections to create tools for visitors.

In every initiative of this progressive digitization process, the components collections and visitors are closely linked, and every action aimed at fulfilling the conservation and scientific functions of the collections provides essential opportunities and materials to enhance their educational and recreational role for the public. Examples of this are the augmented reality proposals made available at the multimedia table in Palazzo Barberini and the tablets for the virtual guided tour of the Corsini Gallery, which use data from the digitisation of the collections to create tools for visitors.

The building. The key role of the last component

The strategies concerning the building, the structure and the facilities, on the other hand, were elaborated in an overall project drawn up for the Lazio-Innova competition

Fig. 5 - Complexity of collection management.

Fig. 6 - Complexity of buiding installations.

in which the Galleries participated in 2018. The technical office of the Galleries had just been set up in the same year. The project arose from the need to control the two locations of the Galleries, in their multiple roles as containers of works of art, as places accessible to visitors, as historical buildings to be protected and enhanced as pieces of art themselves. However, the lack of a recent archive, the chronic lack of data and information on the Palace's structures and facilities, was an obvious problem.

The starting idea, developed together with the Faculty of Architecture of the University of Roma Tre, a partner in the project, was to create a 3D model of the building, based on the various international experiences that are experimenting with HeritageBIM, the BIM modelling applied to a monumental building.

The aim of this first step was to create a neutral matrix, a three-dimensional container ready to incorporate all the data that today the museum has to manage separately and asynchronously, to provide an integrated and simultaneous vision of all the activities involved: the assessment of the structural and plant conditions, the reporting of faults, the management of active and passive safety, the maintenance interventions. All this, reducing costs and improving the administration of the entire museum ecosystem.

Controlling the building component has a major impact on the ability to control and manage all other components. By associating all the data from the collection and the visitors to the 3D model it becomes possible, for example, to know immediately in which rooms the best conditions for hosting a work can be found, or to indicate the walls that guarantee adequate space and light for a painting, how much space and which slots are free in the deposits, how many people can stay in each room, and to intervene in real time on the microclimatic conditions based also on the current crowd.

By associating the model with a web-based platform, all data can be extracted, managed and updated remotely. As in many HBIM experiments being tested today, for the correct functioning of the project idea it was essential to allow also temporal navigation, associating data and documents to a specific moment in time and fixing the state of the structure in the various historical phases.

All this required extremely complex, long and expensive preparatory work. Although the Galleries did not win the funds of the Lazio Innova competition, the management decided to continue the project, but acting by functional clusters. It was decided that each new intervention on the building, even if small, should be accompanied by a 3D model, which will be a new brick in the overall model each time. The reconstruction of the overall model will therefore take place as the sum of the various individual interventions carried out in the coming years.

The first piece of this new incremental strategy will be the 3D survey and photographic reconstruction work that the Galleries are carrying out for the archaeological areas in the basement, which will then be the subject of enhancement projects with VR and AR installations, which will also make them open to the public.

With this idea of an incremental strategy, which will take several years to be realised, the aim is to make Palazzo Barberini a pilot site for the application of the most innovative parameterisation technologies to a complex historical building and the function it contains. The objective is not only to control and manage the building and its systems, but to achieve an integrated management of all components of the museum ecosystem, providing useful tools for the whole museum function.

Notes

1. Since 1946, ICOM (International Council of Museums) has been assisting the world museum community in its mission to preserve, conserve and share Cultural Heritage. To achieve its objectives, ICOM works with institutional partners such as ICCROM, INTERPOL, World Customs Organisation, World Intellectual Property Organisation, maintains a long-standing collaboration with UNESCO and enjoys the status of consultative body to the Economic and Social Council of the United Nations (ECOSOC).

2. Tthe MIBAC decree was then taken over by Decree of the President of the Council of Ministers No 169 of 2 December 2019.

3. One of the aspects of complexity theory elaborated by Niklas Luhmann for social systems, involves an increase in cognitive complexity in order to be able to interpret the complexity and operate a simplification operation: Luhmann, N. (1986). La complexité et le sens. In AA.VV. *Science et pratique de la complexité: actes du colloque de Montpellier, Mai 1984*. Paris: pp. 121-126.

4. SenSi project concerns MEMS sensors for an integrated monitoring system for the preservation, enhancement and use of Cultural Heritage - POR FESR LAZIO 2014 - 2020 Support for the competitive repositioning of production systems and supply chains Public Notice no. 7 "Cultural Heritage and Tourism" - Integrated Projects.

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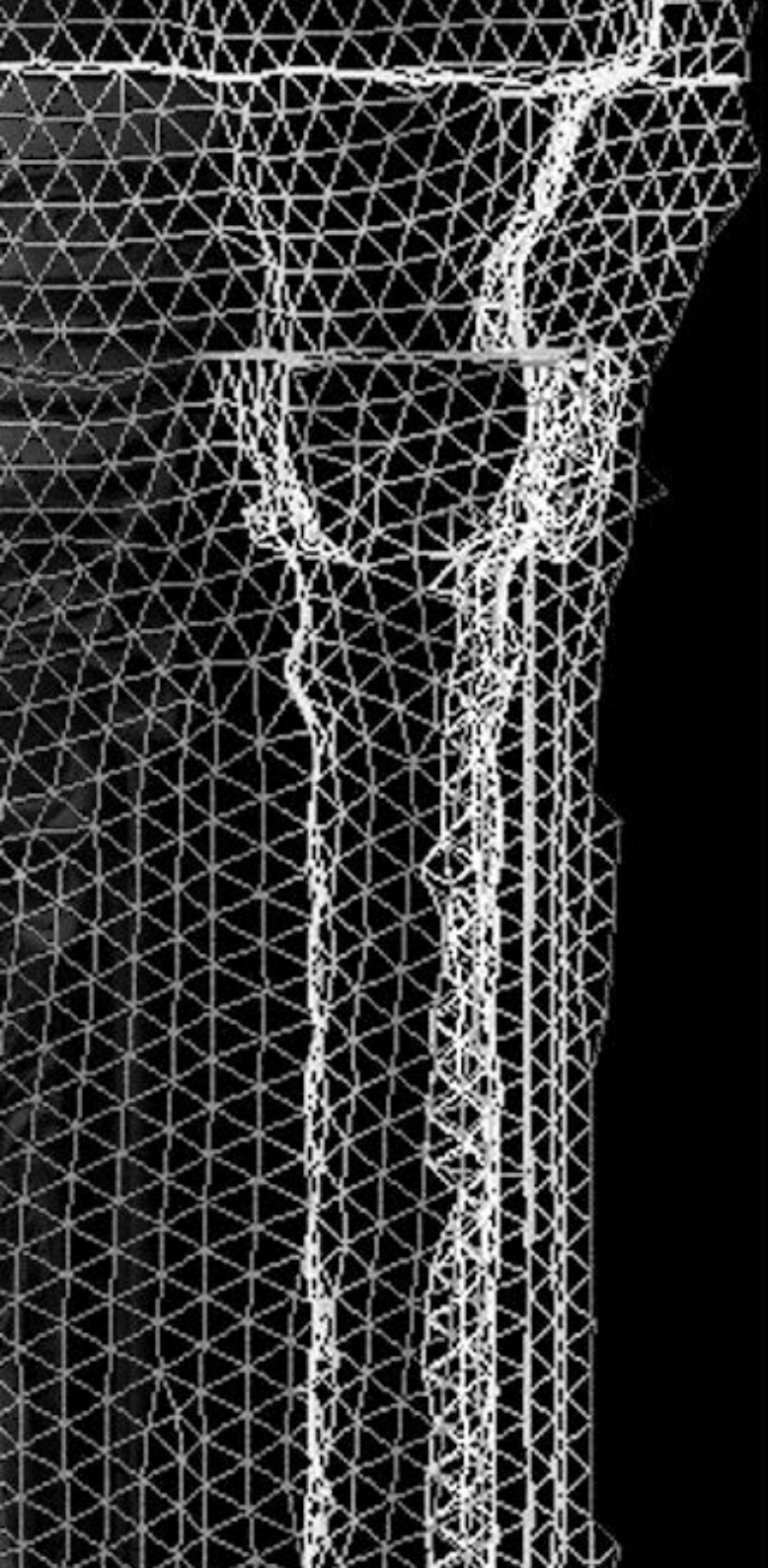

PART I

Elena Ippoliti

Sapienza University of Rome

Sandro Parrinello

University of Pavia

Elena Ippoliti, Architect, Ph.D., Full Professor at Sapienza University of Rome, Faculty of Architecture, Department of History, Representation and Restoration of Architecture (DiSDRA), where she teaches in Architecture and Design courses and also in the Doctorate Course in History, Representation and Restoration of Architecture.
Director of the Master in *Communication of cultural heritage* and of editorial series published by Franco Angeli *Forme del Disegno*, she has authored over 150 scientific publications.
In recent years she has oriented her research towards critical reflection and experimental investigation on the use of digital technologies for the enhancement of Cultural Hheritage. In particular, she has dealt with the definition of visual languages for the knowledge, communication and use of the values of Cultural Heritage.

Sandro Parrinello, Associate professor at Department of Civil Engineering and Architecture of University of Pavia. Ph.D. and European Research Doctor. Since 2012 he's been visiting professor at Perm National Research Polytechnic University and in 2015 he received an honorary degree from the State Academy of Civil Engineering and Architecture in Odessa. In 2011 he was appointed Expert and Voting member for Italy to the international scientific committee ICOFORT (ICOMOS International Scientific Committee on Fortifications and Military Heritage). In 2016 he was Visiting Prof. at Cracow Polytechnic University and in 2017 he obtained the National Scientific Qualification as First Level Professor. He is director of DAda Lab. and of Landscape Survey & Design Lab. of University of Pavia. He is responsible for national and international research projects, member of editorial boards of international scientific series and journals and organized international conferences on the subject of heritage documentation.

DIGITAL CHALLENGES FOR CULTURAL HERITAGE ENHANCEMENT. MODEL INTELLIGENCES BETWEEN COMPLEXITY AND IDENTITY

Elena Ippoliti, Sandro Parrinello

The approach to cultural heritage according to a holistic model is now established policy in Europe. Heritage is considered in its entirety, no longer distinguishing between tangible and intangible, between the actions of creation, preservation and enjoyment. It is a complex system that must be supported, enhanced and promoted on the basis of an integrated approach that must take into account cultural, economic, social, historical, educational, environmental and scientific components.

Culture and cultural heritage are common goods and values, nonrenewable resources that must be preserved according to their authenticity and shared for the possibilities of promoting a European identity and mutual respect.

Therefore, 'digitization for documentation' constitutes itself as a great opportunity, but there is no doubt that it also presents several challenges. For first of all, it needs new participatory models to promote the 'shared resource' aspect and the involvement of communities, on the one hand, and high levels of expertise of operators and quality control systems, on the other.

But more generally, 'digitization for documentation' is constituted as a challenge because of the intrinsic characters of cultural heritage itself, that is, its complexity/heterogeneity, on the one hand, and uniqueness/identity, on the other. Intrinsic characters that reverberate in the definition of 'models,' be they those of documentation or even those of communication.

Evidences posed, along with others, for attention by the Seminar *Digital & Documentation* and which also emerge in the essays presented in this part of the Proceedings.

As for example in De Marco and Dell'Amico's essay, where the case study of the Upper Kama territory and the purpose of the European Cultural Heritage Routes research impose a multi-scalar structuring of knowledge, documentation and communication models.

The relationships between territory and community are resolved by the authors by developing a 'grammar of forms' and defining related models of three-dimensional representation of cultural objects at different scales – landscape, urban center, architecture. Models that are the building blocks for describing architectural features, stylistic variety, construction solutions, degradation pathologies, degree of preservation, etc. This process of morphological, technological and typological semantization, from the territorial level to the architectural scale, is thus the basis of the information modeling protocol which, structured on data queries and descriptors, allows for the description of the identity of the Upper Kama region and the combined management of historical memory, information and interventions.

The reflection proposed by Veronica Riavis and Paola Cochelli instead concerns in particular the communication models, the purpose of which must always be to make the different forms of cultural heritage accessible and understandable to the specifics of the audiences for whom these are designed.

In the essay, the audience is the blind and partially sighted people for whom the authors experiment with various models of haptic communication in relation to the different characters of heritage: architecture, painting and sculpture. Unlike what is usually done in the heritage communication segment, where the privileged sense is that of sight, in this case understanding is entrusted to the interaction of the hands with the surrounding environment. To this end, different operational strategies are proposed for the acquisition of geometric-compositional information and the formal translation of contents into three-dimensional models and two-dimensional relief drawings, in accordance with the specificities of heritage and the purposes of communication.

But 'digitization for documentation' is also a challenge because of certain problematic issues introduced by digital. These include the issue of the relationship between 'data quantity and information quality' critically brought to attention by several other essays.

As, for example, in Valeria Cera's essay, which highlights the problematic issue of the balance between the quantity of surfaces and vertices required to describe an architectural object and the management of the corresponding 3D models with web-based fruition and query platforms, consistent with the scientific aspects of the organization of information resources.

For this purpose, the author develops a protocol for structuring the digital replication of architectural heritage from reality-based survey techniques carried out by automatic decimation algorithms, retopologizing processes and texture baking. The methodological proposal, of which the different operations are described through an illustrative case study, is conducted with reference to the need to restore in the digital replica the identity character of the real object both in terms of geometric coherence and in terms of fidelity and aesthetic quality of visual perception).

The same problematic node is proposed by Michele Calvano, Filippo Calcerano, Letizia Martinelli, and Elena Gigliarelli in the specifics of the relationship between survey data and its use in BIM field, where it's emphasized the fact that the amount of information should be limited to what is strictly necessary, not only for more effective management, but more generally because anything beyond this minimum is waste.

Within this framework, the authors propose a process that postulates the recognition of geometries directly from the scattered cloud of a SfM photogrammetric survey to arrive at modeling and integration of diagnostic data. A kind of topographic survey, where each oriented photo becomes a total station from which to collimate significant points useful for reconstructing two-dimensional primitives.

A workflow aimed at semantic clarity and constructive representation that re-proposes an approach to heritage documentation, so to speak, traditional starting from an analytical approach of geometric conformation to extract from the redundancy of a point cloud the essential

information for the description of the architectural object.
A question also raised by Ramona Quattrini who, through four different case studies developed since 2014, shows the evolution and hybridization of digital technologies in the HBIM segment – from ScanToBIM to Artificial Intelligence applications – proposing a reflection not on the tools but on the implications in the context of Digital Humanities and Computational Modeling.
More specifically, the essay proposes a reflection on the meaning and goals of modeling, showing different ways of incorporating meaningful forms of intelligence for the documentation of the built heritage.
Forms of semantic intelligence that are specific to the discipline of Drawing and that can and should also be incorporated into three-dimensional digital models by developing a grammar of forms, building thesauri, ontologies, taxonomies, etc. An intelligence of models which, also thanks to advances in AI, can be shared by communities interested in the enhancement of built Cultural Heritage in a virtuous process that minimizes waste even in the digital segment of information.
An intelligence specific therefore to the discipline of Drawing, as Matteo Bigongiari's essay on Leonardo da Vinci's design contribution to the modernization of the defenses of the city of Piombino also demonstrates.
An investigation that crosses the different forms of drawing, both analogue and digital: that of Leonardo's authorial signs thanks to the analysis of one of his substantial set of handwritten sheets, that of the configuration of the still existing fortresses around the historic city thanks to survey returns, that of the image of the fortified architecture of Piombino in the 16th century thanks to its digital reconstructive hypothesis, those of the signs of the Renaissance drawings of military architectures thanks to the reading of some of the main treatises of the time.
Essays that collectively demonstrate how the Drawing and the latest technological innovations is not only a tool but an established and powerful scientific method through which to analyze and compare multidisciplinary and chronologically distant data – such as those of design and construction. A method for generating 'intelligence,' that is, a heritage of knowledge and best practices to preserve, share and enhance our past and from which to build our future.

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She received the first level university Master's degree at the University of Udine in *BIM - Expert in Information Modeling and Project Management*.
She is collaborator and contract professor at the Polytechnic Department of Engineering and Architecture of the University of Udine. She is an expert in perspective restitution applied to painted architecture and in inclusive tactile representation for Cultural Heritage through new technologies.

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In the academic year 2020/2021, she teaches the BIM module of the course Digital Design and BIM at the University of Trieste. Since 2010 collaborates with the University of Trieste and Udine in several researches carried out by prof. Sdegno's team and as a teaching collaborator. In 2015/2016, she is research fellow at the DMIF of the University of Udine for the research *Proposal and validation of automatic methods for the control of the virtual camera in the fruition of architectural model*, scientific responsible prof. R. Ranon (PRIN 2010-2011).

01 TACTILE REPRESENTATION OF CULTURAL HERITAGE: RESEARCHES BETWEEN ART AND ARCHITECTURE IN THE ISONZO AREA

Veronica Riavis, Paola Cochelli

Abstract

The advanced technologies of representation and communication can provide new methods for the fruition of Cultural Heritage. Recently the role of tactility is becoming central in extending the knowledge of artworks to a wider audience, overcoming 1impediments and perceptual barriers that in the past did not allow the enjoyment of artistic assets, for example to blind and partially sighted people. The application of appropriate procedures to Isonzo sculptural, architectural and pictorial masterpieces allowed the reproduction of tactile copies with a high informative content.

Tecnologie avanzate di rappresentazione e comunicazione possono fornire nuove metodologie di fruizione dei Beni Culturali. Di recente il ruolo della tattilità sta diventando centrale nell'estendere la conoscenza di opere a un'utenza ampliata, superando impedimenti e barriere percettive che in passato non permettevano il godimento di beni artistici, ad esempio a persone non vedenti e ipovedenti. L'applicazione di opportune procedure a significative opere isontine di natura scultorea, architettonica e pittorica ha consentito la riproduzione di copie tattili ad alto contenuto informativo.

1. Introduction to tactile representation

The aim of the research is to investigate the ways to make the different forms of art more accessible and understandable to a wider audience, with particular attention to people with visual impairments.
The understanding of art can take place thanks to reproductions obtained from the integration of acquisition and modelling procedures in accordance with the requirements of tactile perception.
For this specific field of representation it is fundamental to understand what are the recipients' needs and the tactility precepts useful for the real translation and comprehension of an artefact. From dimensional point of view, the reproduction of an artwork must provide for a contained extension since the field of tactile understanding is restricted to the interaction of the hands with the surroundings.
The sense of touch is unable to perform refined investigations and it needs simplified or enlarged relief images to highlight small details. Simplification also makes it possible to read the work and understand its characters in an adequate amount of time.
Congenital blindness encounters the main limitations for the understanding of art: the interpretation of relief figures requires considerable effort[1] and the understanding of perspective[2] and colours[3] is difficult [Grassini 2000; Grassini 2015]. Therefore, user manuals and specific procedures that educate and accompany a blind person to read a work of art – be it authentic or reproduced – in order to be able to generate the 'mental image' of the analysed object[4] are indispensable.
To design and verify tactile reproductions, it is also essential to collaborate with expert staff, specific bodies such as the Italian Union of the Blind and Partially Sighted (Unione Italiana dei Ciechi e degli Ipovedenti), and institutes that deal with the use of artistic assets for particular cases.

2. Tactile reproductions for the Isonzo area

For this research on tactile reproduction of Cultural Heritage, we have worked on significant architectural, pictorial and sculptural emergencies of Gorizia city.
Given the specificity of the subjects involved in haptic restitution, we have developed different operational strategies for the acquisition of geometric-compositional information and formal translation of content (three-dimensional models and two-dimensional relief drawings).
The sites concerned various areas: architectural, pictorial and sculptural. For the architectural context, we studied the tactile translation of the baroque church of Saint Ignatius (3D model and a tactile map of place) and the castle of Gorizia (two tactile maps of place with different degrees of detail). For the painting context we reconstructed the illusionist fresco *Glory of St. Ignatius* preserved in the above-mentioned church (3D model), while for sculpture we made scale copies of two *Character Heads* by Franz Xaver Messerschmidt.
We conducted these representation researches within two Ph.D. theses in Civil Environmental Engineering and Architecture between the Universities of Trieste and Udine and the project *Gorizia conTatto* promoted by Italia Nostra Onlus[5].
Experts in the field of tactile representation from different museums and institutions for the blind have tested and verified the designs and prototypes here presented.

2.1 The tactile reproduction of architecture and painting: three-dimensional models of the church and the Glory of St. Ignatius

The three-dimensional representation is closer to a blind person, because it is the most used to investigate and interact with the surrounding reality. For this reason, we agreed that the all-round form was the most suitable to create physical prototypes (reproducing the spatial, geometric

Fig. 1 - The church of St. Ignatius in Gorizia: the main façade (left) and the illusionist fresco of the presbytery by C. Tausch, 1721 (right).

and decorative architectural aspects) of the church of Saint Ignatius and the fresco painted inside (fig. 1).
The late baroque church built by the Society of Jesus between the 17th and 18th centuries has a main façade with two twin bulbous bell towers and a giant order of composite columns. The interior space has a single nave covered by a barrel vault flanked by three chapels on each side surmounted by women's galleries.
The building is devoid of transept, dome and apsidal conclusion.
Through 3D laser scanner surveys, we defined the volume of the building, in order to obtain an architectural model metrically accurate and proportioned in all its parts thanks to the union of 44 scans. Starting from the point cloud, we modelled the structure and the decorative elements of the architecture through Boolean operations. In this

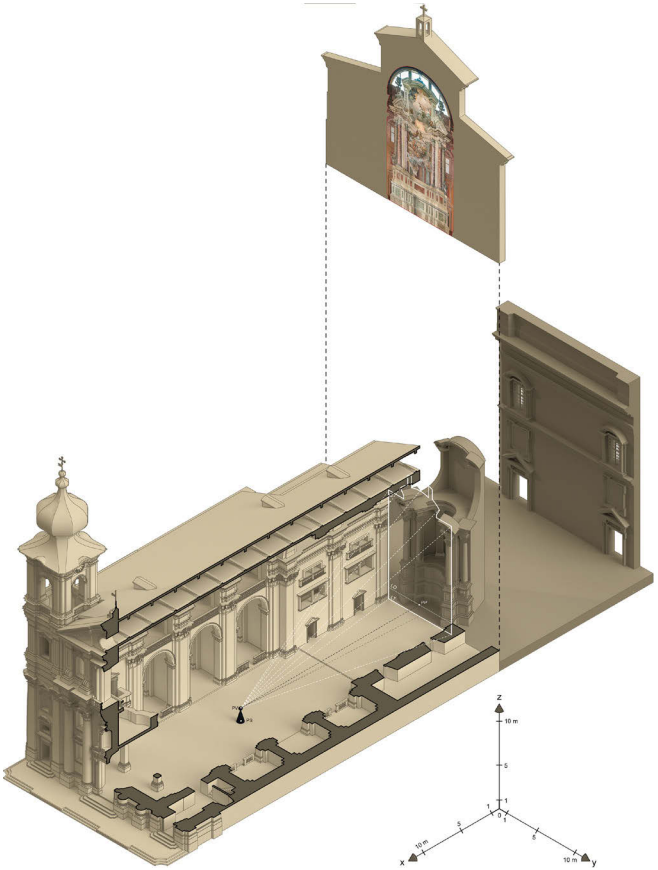


Fig. 2 - Axonometric cross-section of the digital model of the church and of the painted architecture reconstructed through perspective restitution (elab. V. Riavis).

Fig. 3 - Comparison between painted and modeled architecture at the point of view of the painted perspective (elab. V. Riavis).

phase we tried to maintain a degree of detail that would allow the effective comprehensibility both as regards the tactile perception and in reference to the scale of reproduction chosen (1:100) and the technology used to create the physical model (FDM rapid prototyping).
According to the maximum size of the space required by the printing machines, we divided the digital model of the church into 118 pieces of varying size, detail and production time (46 for the exterior and 72 for the interior, for 854 hours of production). The model of the church excludes the part of the rectory and has maximum size of 33 x 60 x 50 cm.
On the other hand, the tactile translation of the painting is a much more complex operation, which has different interpretative keys. To make a scene represented on a dimensional plane "tactile", one of the most widely used techniques is relief drawing. From these reproductions, the blind person perceives the highlighted outlines of the main shapes and identifies materials and colors according to different textures. This simplifying technique, however, requires a process of abstraction not easily achievable in congenital blindness [Riavis 2020]. If the scene is populated by several characters, the best solution is to create a perspective bas-relief with undercuts, a technique developed by hand at the Institute for the Blind Francesco Cavazza and its Anteros Museum in Bologna [Gualandi, Secchi 2000; Secchi 2005].
For the illusionist fresco *Glory of St. Ignatius*, we chose instead to experiment a scientific methodology to reconstruct the pictorial scene represented: the perspective restitution. The quadrature covers an area of about 200 m^2, painted in 1721 by Christoph Tausch (1673-1731), prolific Jesuit artist and architect in Central Eastern Europe and student of Andrea Pozzo (1642-1709). The fresco is predominantly composed of two architectural scenes, as well as a figural character: an altar with an accidental placement of the orders and semi-circular conclusion, and a background simulating an elevation with false doors and windows that increases the perception of depth.

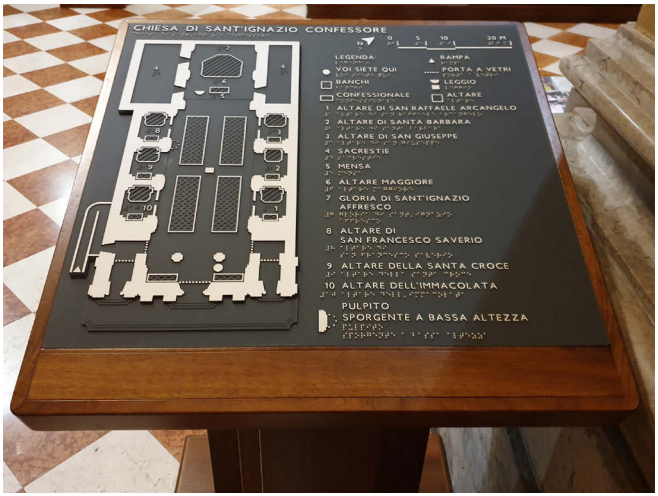
Fig. 4 - The tactile prototypes of the church of St. Ignatius (a) and of the fresco illusionistic architecture (b). Modeling and prototyping by V. Riavis, realization at the 3D LAB Laboratory, University of Udine, Polytechnic Department of Engineering and Architecture.

Fig. 5 - Tactile map of the place of the church of St. Ignatius of Gorizia. Project by V. Riavis, realization by Incisoria Vicentina.

With semi-automatic photogrammetry, we obtained an orthogonal mosaic frame of the entire wall thanks to which we started the procedures of perspective restitution. The graphic process allowed us to acquire the spatial information of the represented architectural elements and to establish the observation point of the illusionistic perspective identified at the centre of the church (29 m for the main distance from the painting and observer's height equal to 1.81 m). The geometric results formed the basis for modeling the painted architectural composition in a digital environment, and then dividing it into 10 pieces for rapid prototyping (for 77 production hours) [Riavis 2020].
By making the two digital models of the real and illusory architecture interact, it is possible to simulate the spatial dilation of the space that extends 25 cm in depth. In fact, by removing the physical limit of the wall of the presbytery where the fresco lies, we can reveal the spatial deception of the illusionistic perspective (figs. 2, 3).
We have chosen the scale 1:100 to give the possibility also to blind people to appreciate the model in its entirety and to understand the relationship between real architecture and pictorial scene. The prototype of the building, which can be opened in correspondence of the longitudinal half and the removable roof allows exploring it in all its parts [Sdegno, Riavis 2020].
Finally, to optimize tactile perception, we smoothed the surfaces and joints by removing any sharp or layered elements due to the deposition of the PLA material (fig. 4).

2.2 The tactile maps of place for the church of St. Ignatius and the Castle of Gorizia

For *Gorizia ConTatto*, an inclusive initiative promoted by Italia Nostra section of Gorizia, we have developed some project solutions for tactile installations in significant sites of the city. The aim was to facilitate access to the local Cultural Heritage also to blind and partially sighted.



Among these tactile locations, we developed three tactile maps of place for St. Ignatius church and the castle [Riavis, Cochelli 2018].
Tactile maps of place are different from the better-known route maps, extremely simplified and graphically devoid of proportion, installed in public places to facilitate orientation and knowledge of specific services. Although simplified, maps of place are more realistic, because these relief representations communicate the geometry and most significant contents of a certain environment. Blind or partially sighted can read them by spending more time understanding the characteristic aspects of the building or site they are visiting.
In designing the maps, we employed the same graphic choices, trying to highlight the main shape of the buildings, the artistic contents and the potential elements of danger. For the church, the simplified plan represents the building sectioned at height of +0.40 m from the floor of the nave. In this way, the map describes the interior wall envelope perceptible with the white stick, points out the differences in level (external stairways, ramps, steps of

Fig. 6 - The castle of Gorizia (top) and court of the Lanzi (bottom).

the chapels, descent into the left sacristy) and excludes the windows.

The map represents all the main rooms of the building (nave, dedicated chapels, presbytery, sacristies) and excludes those inaccessible to the public. It also indicates the particular artistic contents of the 18th and 19th centuries (pews, confessionals, altars, ambos, frescoes), but also potential dangers during walking (glass doors, low pulpits, height differences) diversified by textures and numbers distinguishable by touch and explained in the legend. For orientation and understanding the building size, there is a north indication and a graphic scale above the legend.

The map is located inside the church on a wooden support at the point indicated by the words "you are here". It is 600x550 mm and it is made of acrylic plex finished with opaque anti-reflective paint with white relief on a dark grey background to facilitate reading to partially sighted people (fig. 5).

In parallel to the church of St. Ignatius, we designed the tactile map of place for the castle of Gorizia. The fortress is located on a hill and is composed of buildings from different periods (from the 11th to the 26th century) that hold an inner courtyard. The complex currently houses a museum and it is located in a village enclosed by rampart walls, reachable by blind people also thanks to a tactile path (fig. 6).

After the inspections carried out with the person in charge of the project and due to the complexity of the site, we decided to proceed by successive levels of investigation and to create several relief maps to be located in different points of the castle. For the design of the two plans was performed a survey by 3D laser scanner and photogrammetric procedures of the type structure-from-motion compared and integrated by the pre-existing cartographic documentation especially related to the philological restoration of the manor occurred from 1934 to 1937 after the bombing of the World War I [Amoruso, Cochelli, Riavis 2018].

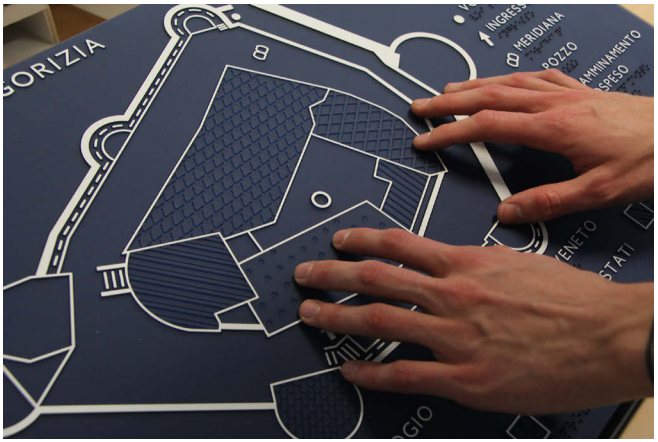


Fig. 7 - General tactile map of the castle of Gorizia. Project by P. Cochelli, realization by Incisoria Vicentina.

Fig. 8 - Tactile map place of the castle of Gorizia. Project by P. Cochelli, elaboration by Incisoria Vicentina.

We have chosen to place the first map within the first walls, in a covered area to avoid damage due to exposure to atmospheric agents (rain, wind, sun). It represents the conformation of the castle including the walls interspersed with bastions and the complexity of the different architectural volumes of the palaces.
Given the geometric complexity of the structure and on the suggestion by experts of tactile representation, we have not identified the different palaces with alphanumeric inscriptions, but we have opted for textures, easier to identify by touch. The legend specifies the symbols and textures contained in the relief plan. Also in this map, we have inserted the metric scale and the north orientation. The final map has a size of 600 x 400 mm and facilitates reading to partially sighted people by exploiting the colour contrast between the blue background and the white relief (fig. 7).

Planned for the entrance to the museum, the second tactile map represents the articulation of the ground floor of the castle. With the same criterion adopted for the first one, in this relief plan we have inserted different textures for larger surfaces and precise indications to describe the rooms or the significant elements available to the visitor.
The map has the same size and colors as the previous one, maintaining a graphically congruous guiding thread (fig. 8).
We accompanied the projects of the place maps with study prototypes made with cardboard and plastic sheets with different textures tested by tactile representation experts from the 'Rittmeyer' Regional Institute for the Blind of Trieste, the 'Cavazza' Institute – 'Anteros' Museum in Bologna and the 'Omero' State Tactile Museum of Ancona.

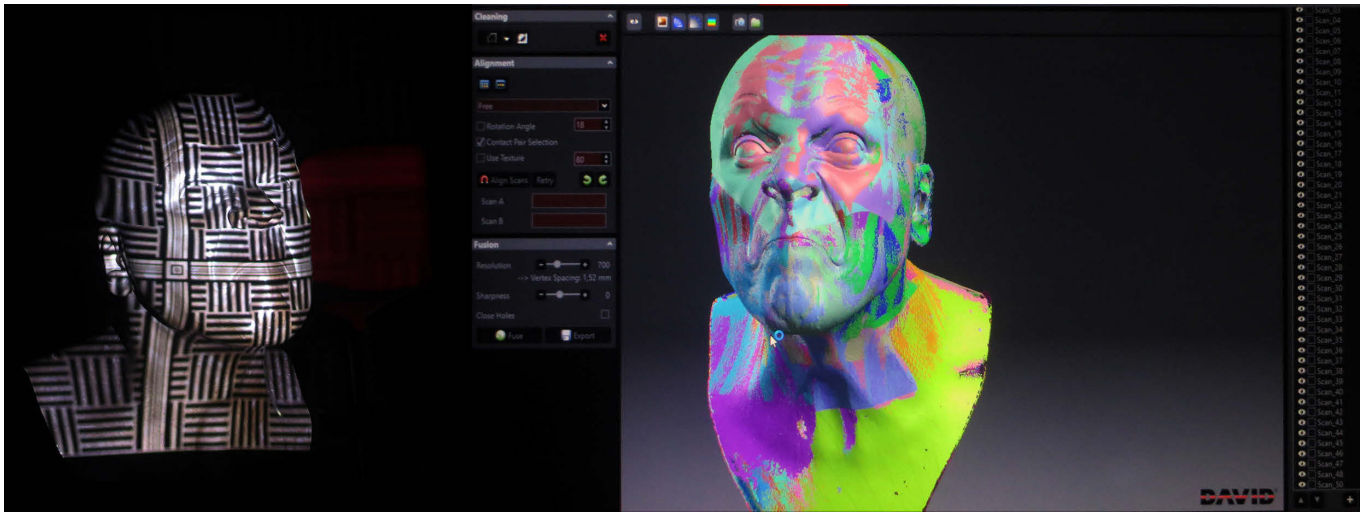


Fig. 9 - F. X. Messerschmidt, Heads of character: Man looking at the Sun (left); Sneeze (right), 1770-1780), Palazzo Coronini Cronberg Foundation, Gorizia.

Fig. 10 - 3D acquisition with structured light scanner: projection of patterns (left); superposition of the scans (right). Elab. R. Camponogara.

Fig. 11 - Comparison between the two sculptures and their three-dimensional digital copies after the treatment phase. Elab. R. Camponogara.

This dual approach of representation made it possible to identify the appropriate size that the plans should have presented and the actual perception of the constituent elements, before proceeding with the creation of the final maps.

2.3 Reproduction of sculptures: the Character Heads by F. X. Messerschmidt

Also for the *Gorizia conTatto* project, we participated in the tactile reproduction of two sculptural busts belonging to the collection of the Palazzo Coronini Cronberg Foundation[6] [Sdegno, Cochelli, Riavis, Camponogara 2017].

These are the only two *Character Heads* in Italy by Franz Xaver Messerschmidt (1736-1783), court sculptor of Maria Theresa of Habsburg, part of a series of over 60 similar busts located in the most prestigious museums around the world (fig. 9).

The artworks represent self-portraits of the author who immortalize curious facial expressions made in the throes of paranoid schizophrenia.

After the auction sale of another sculpture of this extensive work by the artist, the Foundation estimated those in their possession and they turned out to be of considerable value (overall valued about 8 million euros), which is why they are been placed in protective cases with alarm system, removing them from direct use.

To increase knowledge and dissemination of artifacts, making them equally accessible to blind people, the *Gorizia conTatto* initiative proposed to create full-scale copies of the two busts available for tactile exploration.

For this purpose, the research team adopted various non-invasive 3D survey technologies to obtain the best degree of detail while respecting the artwork. At first, we used a scanner that works by automatic interpolation of photomicrographs. Despite the high resolution of the device, the scans was not satisfactory for the quality of the final product we wanted to achieve. In fact, the acquisitions did not identify the expression lines that characterize these sculptures.

We therefore resorted to a structured light scanner that uses the projection of 27 patterns on the surface to register the geometry. For each sculpture, we acquired 60 scans divided into 3 different inclinations (front, top and bottom) which we joined by identifying homologous points (fig. 10).

We then proceeded with the rapid FDM prototyping of the two digital copies (fig. 11). For a faithful reproduction of the sculptures and their characteristic surfaces, we have adopted very high printing parameters and we have rotated the models to optimize the manufacturing properties of the production machine (fig. 12).

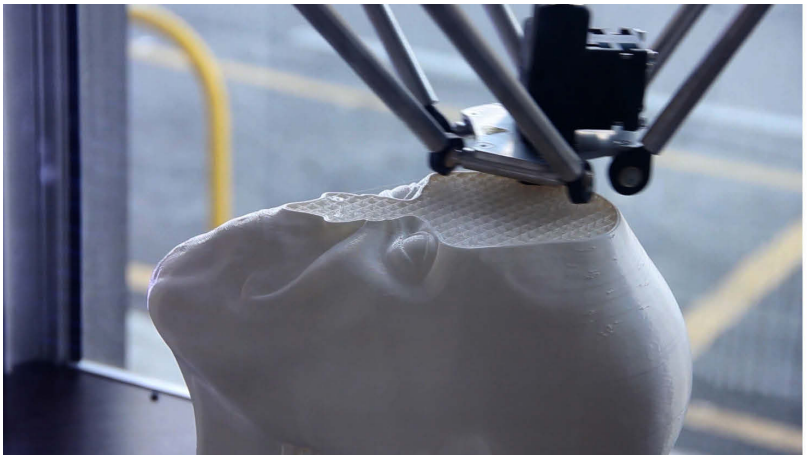
Due to the position of the elements, we inserted supports to compensate the presence of overhangs and holes in the prototyping phase, producing the two sculptures in an estimated time of about 25 hours each.

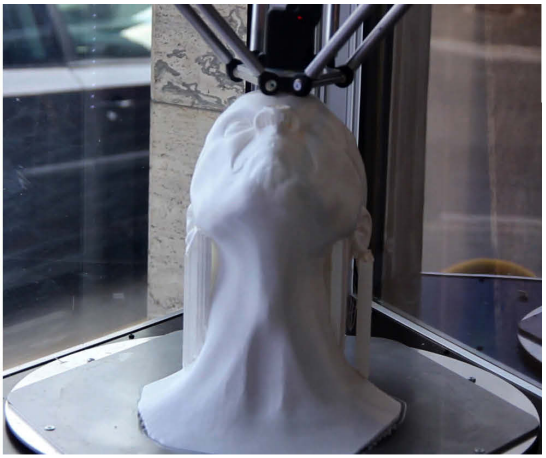
To conclude and refine the result, we cleaned, sanded and painted the prototyped copies to make uniform the surfaces. Currently exhibited in the museum of Palazzo Coronini Cronberg in front of the originals, the two tactile copies of the Heads of Character are available to everyone (fig. 13).

3. Conclusions

For the purpose of correct tactile representation, there is no real universally applicable method of representation, but it is necessary to identify on a case-by-case basis the most appropriate one, which is able to highlight specific aspects that we want to communicate [Riavis 2019].

By simplifying the details within the perceptible tactile threshold (0.5 mm) and depending on the scale, all-round models of architecture and sculptures are preferable. Tactile maps are also very useful to represent the shape





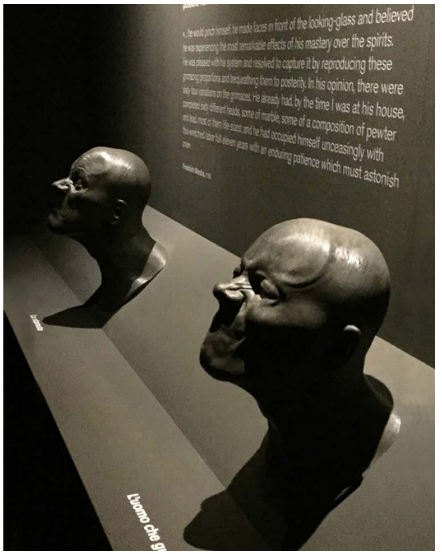


Fig. 12 - 3D printing with FDM rapid prototyping. Elab. Loudlab Studio.

Fig. 13 - Character heads by Messerschmidt (left) and their tactile copies (right) in the permanent exhibition of Palazzo Coronini Cronberg, Gorizia.

and contents of a building or site, this is because a blind is very often used to knowing and reading route maps. The relief drawing technique is also widespread to represent the architectural elevations in two dimensions. The help of assistants and specialized guides who lead to the reading of the form and contents of the reproductions – three-dimensional, bas-relief or obtained from multiple techniques of relief drawing – is fundamental, regardless of the presence of descriptions in Braille or audio guides.
In fact, for the communication of paintings to blind people, simplified relief drawing or bas-relief is often used, which allows an idea of the composition of a scene through silhouettes, but does not allow a real perception of spatial depth, which we can reconstruct where possible through principles of reverse perspective.

Notes

1. The blind person is accustomed to know objects in three dimensions: the operation of compressing them on a plane and transforming them into an abstract two-dimensional form is not immediately reachable.

2. Perspective is a projection onto a plane of a three-dimensional scene, which a congenitally blind person will never experience. We can explain the perspective mechanism only on a purely conceptual level that requires a high level of abstraction.

3. For the congenitally blind, colour is an abstract word with no real reference, which can only be understood through associations of ideas.

4. The mental image is made by an initial general manipulation of the object and subsequent exploration to capture its details.

5. The Gorizia section of Italia Nostra, in collaboration with the UICI, has launched the Gorizia conTatto project for the creation of an integrated accessibility system to the historical and Cultural Heritage of Gorizia for blind and partially sighted people. The itinerary includes the Castle, the Great War Museum and the Fashion Museum, the Synagogue, the Church of St. Ignatius, Attems and Coronini Cronberg Palaces. Supervisor Dr. Maddalena Malni Pascoletti, project supported by the Municipality and the Carigo Foundation.

6. We developed the research activity within the working group coordinated by Prof. Alberto Sdegno of the ADD.lab of the University Pole of Gorizia, seat of the five years Master's degree course in Architecture of the University of Trieste, with the collaboration of the Loudlab studio for treatment and printing.

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02 LEONARDO DA VINCI AS A MILITARY ARCHITECT IN PIOMBINO: A METHODOLOGY FOR THE INTERPRETATION OF RENAISSANCE DRAWINGS THROUGH DOCUMENTATION AND DIGITAL REPRESENTATION

Matteo Bigongiari

Abstract

The intent of the paper is to describe the operating model adopted in the research that guided my recent doctoral studies, in order to propose a methodology that could be useful in addressing similar issues. The research focuses on the analysis of a set of handwritten sheets by Leonardo da Vinci, mostly contained in the Madrid Code II, which describe, like a notebook, his activities as a military architect carried out around 1504, and in particular the modernization of the defenses of the city of Piombino, capital of the Signoria linked to the Appiani family.

To understand Leonardo's design intentions, a multidisciplinary approach was developed that took into consideration a precise analysis of the archival historiographic sources, a careful architectural survey of the military structures still existing today in Piombino, the study of bibliographic sources to understand the figure of Leonardo in his activity as a military architect and the study of the evolution of the fortifications from the mid-15th century and the relationship with other architects of his time.

The research project finally made it possible to understand how important the Piombinese project was within the career as a military architect that Leonardo had undertaken. Thanks to a precise analysis of the existing fortifications, it was possible to clarify which interventions recommended by Leonardo were actually carried out, in order to be able to give an image to Leonardo's achievements and projects on the theme of modern fortifications.

L'intento del *paper* è descrivere il modello operativo adottato nell'approccio alla ricerca che ha guidato i miei recenti studi dottorali, in modo tale da proporre una metodologia che possa essere utile nell'affrontare simili tematiche. La ricerca si concentra sull'analisi di un corposo insieme di fogli manoscritti di Leonardo da Vinci, contenuti per lo più nel Codice di Madrid II, che descrivono, come un quaderno di appunti, le sue attività di architetto militare svolte attorno al 1504, tra le quali largo spazio è affidato all'ammodernamento delle difese della città di Piombino, capitale della signoria legata alla famiglia Appiani.

Per comprendere le intenzioni progettuali leonardiane è stato sviluppato un approccio multidisciplinare che tenesse in considerazione una precisa analisi delle fonti storiografiche d'archivio, un attento rilievo architettonico delle strutture militari esistenti ancora oggi in Piombino, lo studio delle fonti bibliografiche, lo studio dell'evoluzione delle fortificazioni dalla metà del '400 e il rapporto con gli altri architetti a lui contemporanei.

Il progetto di ricerca ha permesso infine di comprendere quanto importante fosse il progetto piombinese all'interno della carriera da architetto militare che Leonardo aveva intrapreso. Grazie a una precisa analisi delle fortificazioni esistenti è stato possibile chiarire quali interventi consigliati da Leonardo sono stati realmente realizzarti, in modo da riuscire a dare un'immagine alle realizzazioni e ai progetti leonardiani sul tema delle fortificazioni moderne.

Introduction

The paper aims to illustrate a survey methodology which, thanks to the possibilities provided by digital documentation, exploiting the results of a detailed instrumental survey and integrating the knowledge on historical and historiographic sources, together with the analysis of Leonardo da Vinci's manuscript codes, allows to deepen the knowledge of his projects and achievements in the field of military architecture.

The interpretation of the drawings and manuscripts produced by Leonardo has aroused the great interest of scholars of different disciplines, who over time have thoroughly analyzed the writing, the ductus of the master, and have categorized the numerous drawings that have served to outline the scientific interests, that have followed one another during his life[1]. Some of these papers concern the architectural field [Pedretti 2006] and some more specifically military constructions [Marani 1978]: the commitment to the representation of ideas and practical solutions for the modernization of military structures has been a constant interest since the first period spent at the Sforza court as a very topical and strictly necessary topic in the palaces of power[2].

The fortification project of the city of Piombino has been studied and evaluated since the discovery of the Madrid manuscripts on the basis of the texts accompanying the pages of the manuscript; no study, although numerous scholars have given their own explanation to the sheets[3], has clarified all aspects of Leonardo's project.

On the basis of previous research, a first moment of reflection was necessary to set up an approach to research that could bring new knowledge to the modernization project of the military defenses of

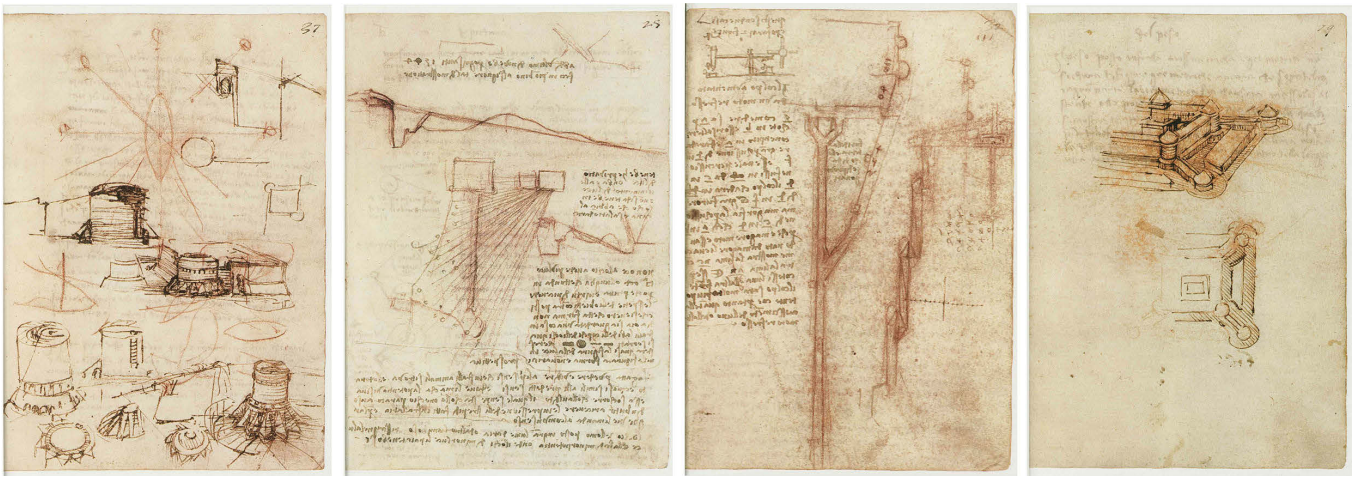


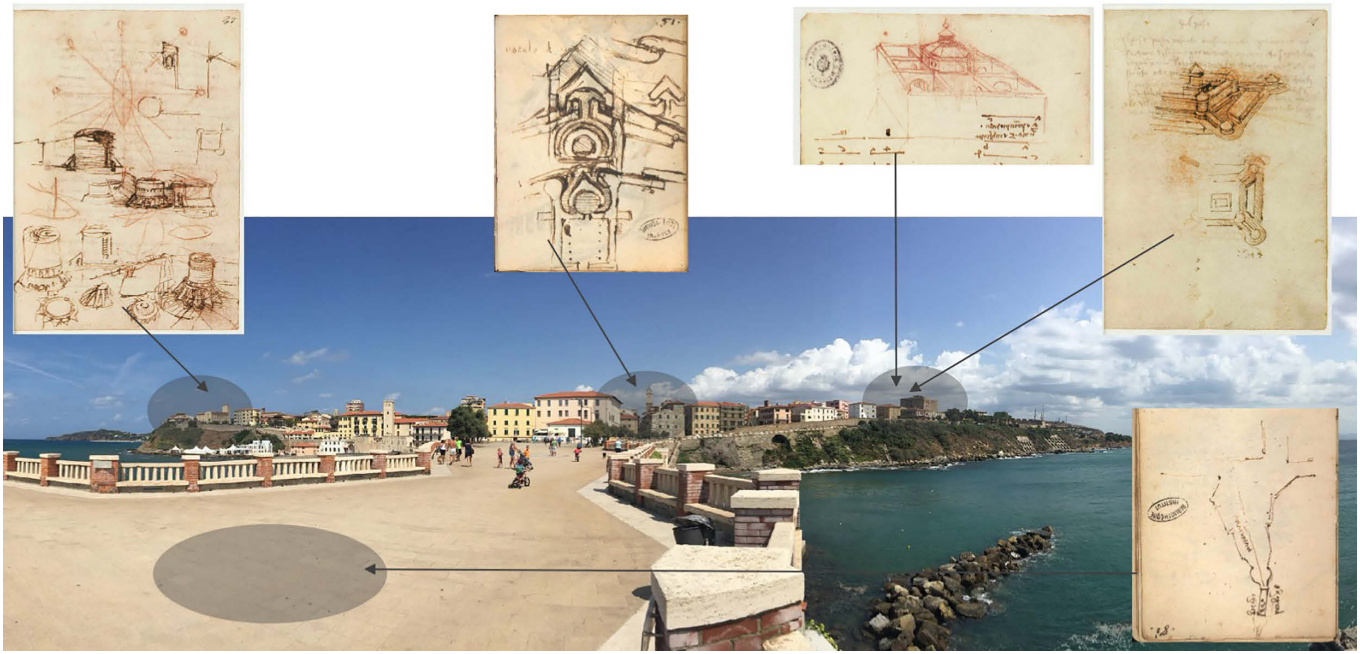
Fig. 1 - Some pages of Codex II of Madrid representing the studies for Piombino.

Fig. 2 - View of the promontory of Piombino with identification of the fortifications involved in the Leonardo da Vinci project.

Piombino, and that had as its fulcrum of the analyzes those related to design, survey and representation of architecture.
The direct study of Leonardo's pages is a very current topic in the fields related to digital documentation and thanks to modern three-dimensional reconstruction technologies it has been possible to deepen many of the morphological knowledge and analyze in detail the traits used in some of the master's main drawings [Gaiani, Apollonio 2017]. Some international researches have also investigated issues related to civil and religious architecture through the study of the drawings of the codes and the creation of three-dimensional models that represent the digital copy of the buildings designed by Leonardo[4].
Taking a cue from the analysis of the drawings and the modeling of the architectures represented by Leonardo, an attempt was made to specifically link the issues with the survey as a fundamental element of knowledge to base the hypotheses of attribution of the forms represented and annotated by the master in his notebooks[5].

Methodology

The complexity in the research design consists in the method of analysis of Leonardo's manuscripts: the drawings that are being discussed specifically, which historians have rightly attributed to the projects for the modernization of the Piombino defenses of 1504, are only preliminary sketches to the project, made quickly. The Madrid Codex II, which contains the majority of the pages that can be referred to Piombino, must be seen as a travel notebook, in which Leonardo quickly wrote down



his thoughts through text and drawing: in fact, in this code there are many references to all the experiences that Leonardo had in 1504, serving the Republic of Florence, from the representation of the course of the Arno river, whose deviation project is famous, to the study of the Pisan mountains and its fortifications in particular the Verruca in the fight against Pisa. It was also Leonardo's practice to reuse the pages of his notes when needed to write down what was urgent at the moment; therefore, there are often multiple representations, some of which are directly linked to projects for Piombino, hidden under rivers of text that Leonardo had subsequently annotated with different ink.
As we are talking about notebooks and not definitive drawings, it must also be borne in mind that the dimensions of the pages, and therefore of the drawings, are particularly small; the sketches represent the design ideas, or the findings of the state of affairs, of Piombino's military architecture, but the reduced size of the pages leads Leonardo to synthesize the graphic signs, describing only the shapes of the objects on which he wanted to focus attention: if it could already be complex to recognize the architectures currently present in the territory in the forms drawn in the documents of the late fifteenth century, it requires a greater interpretative effort to do so on drawings that are not excessively detailed. On the other hand, the synthetic nature of the drawing makes it easier to understand Leonardo's intentions, and the main architectural elements on which his intention dwells.
The pages of the manuscript are also accompanied by the text which, while in the case of reused pages it can only be misleading or annoying in the understanding of the underlying image, very often instead serves to understand

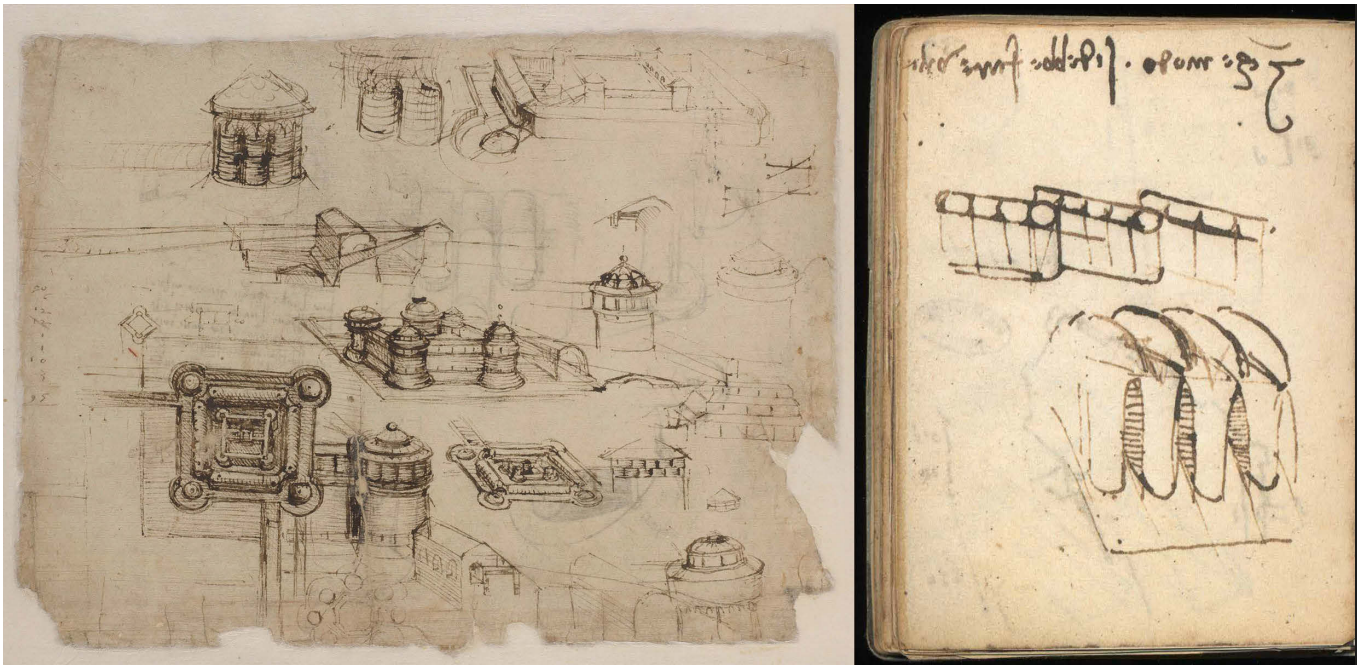


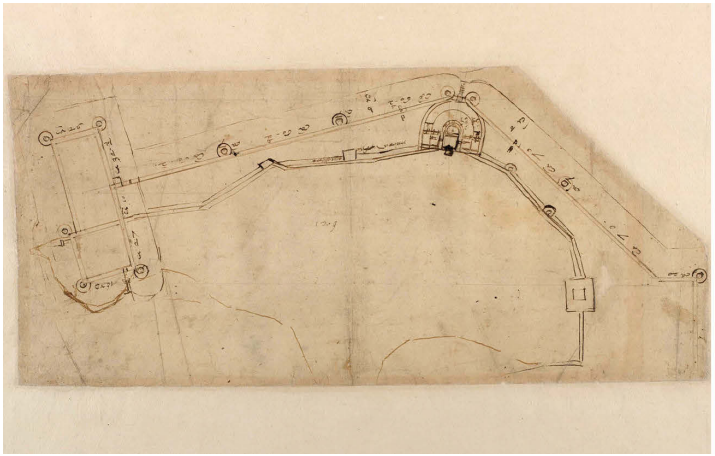
Fig. 3 - Leonardo da Vinci's military architecture studies carried out around the same period as the design for Piombino.

Fig. 4 - Images of military architecture from the codices of Francesco di Giorgio, which Leonardo had studied in depth.

more clearly the use of Leonardo's drawing that he annotates, for example, the size of the works to be carried out with the intention of estimating the costs, or how to protect the castle from enemies through a careful design of the Citadel. These pages were the most useful in the first studies related to the Madrid code and the activity for Piombino, because both the city and its main fortifications could be found named in the texts.

To bring Leonardo's images back to precise design indications for the modernization of the defenses, it was necessary to carry out an important study on the fortresses that still exist around the historic city. This study was conducted on a morphological and historical level: the operation was in fact aimed at reconstructing, as far as possible, the image of the fortified architecture of Piombino as it had been seen by Leonardo's eyes, thus trying to put himself in the shoes of the military engineer who visits the city, carries out a first inspection of the fortifications and proposes a first project idea that improves the defense system which is now unsuitable to respond to the consolidated use of firearms.

When we talk about information on a morphological level, we refer to the practice of architectural survey which is configured as an essential moment of knowledge for the analysis of the monument; considering to compare Leonardo's drawings, both those on an urban scale and those on an architectural scale, with the same buildings that have undergone numerous transformations over time, it is important to superimpose the shapes of objects that can really be compared with each other: plans updated with planimetric drawings for the design of the military system, sections and plans regarding the design of military buildings.



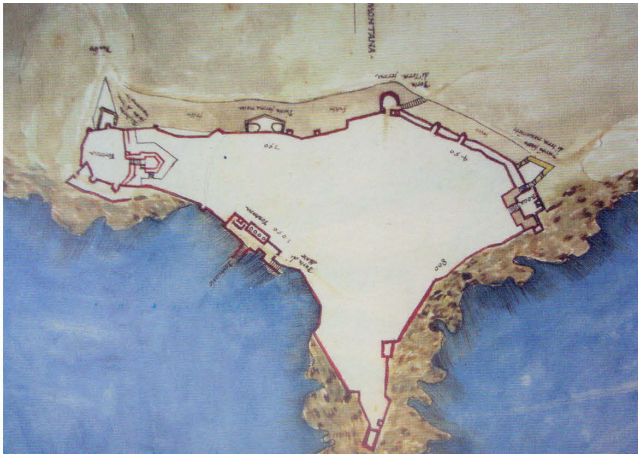
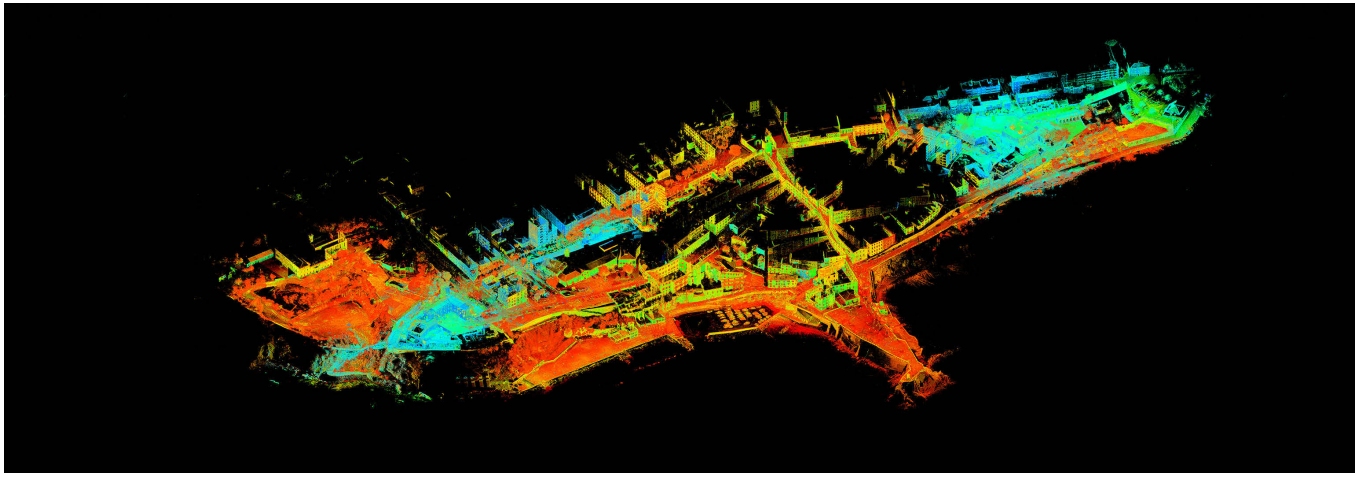


Fig. 5 - Survey of the fortifications of Piombino before and after the arrival of Leonardo da Vinci.

Fig. 6 - Laser scanner survey of the entire fortified perimeter of the historic city of Piombino.

Fig. 7 - Detail laser scanner survey of one of the military buildings.

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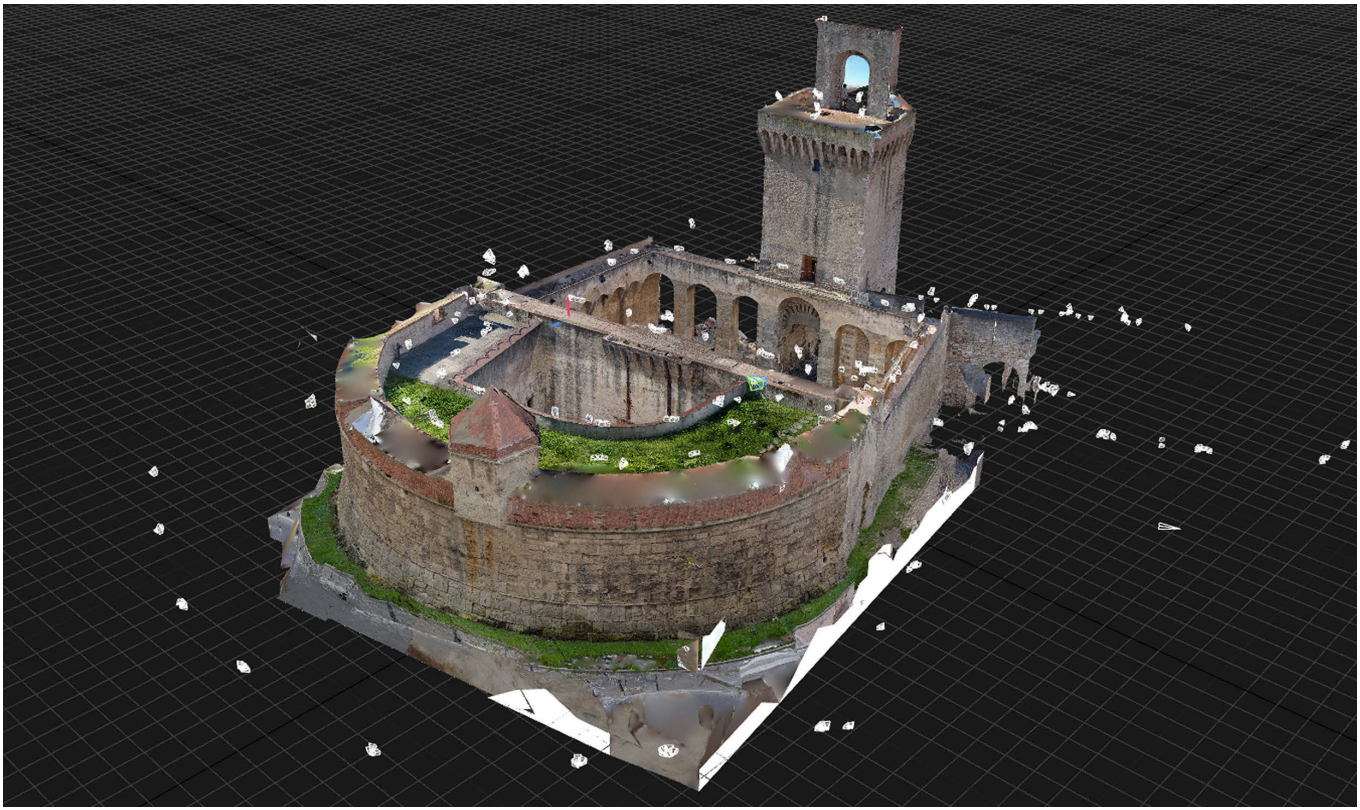


To obtain these documents, numerous architectural surveys were conducted, with instruments that exploit range-based and image-based technologies: the information extracted from the laser scanner made it possible to reconstruct complete point clouds of the entire system of fortifications of Piombino, from which accurate graphical drawings were extracted, which allowed to study both the plan of the entire fortified system and the architectural detail of the main buildings that make up the defenses, namely the keep, the Citadel and the ravelin of the Porta di Terra [Bertocci, Bigongiari 2020].

The survey documents allowed a first comparison between the forms of fortified architecture present in Piombino and Leonardian sketches; however, this operation is not sufficient to compare the meaning of the lines drawn by Leonardo with what remains of the buildings: in fact since 1504 the fortresses have undergone numerous changes, at first related to the defensive modernization process, while at a later time, and in particular from the end of the French domination of the 800, it was necessary to convert the function of these buildings they no longer had any key role in the defense of the territory. These

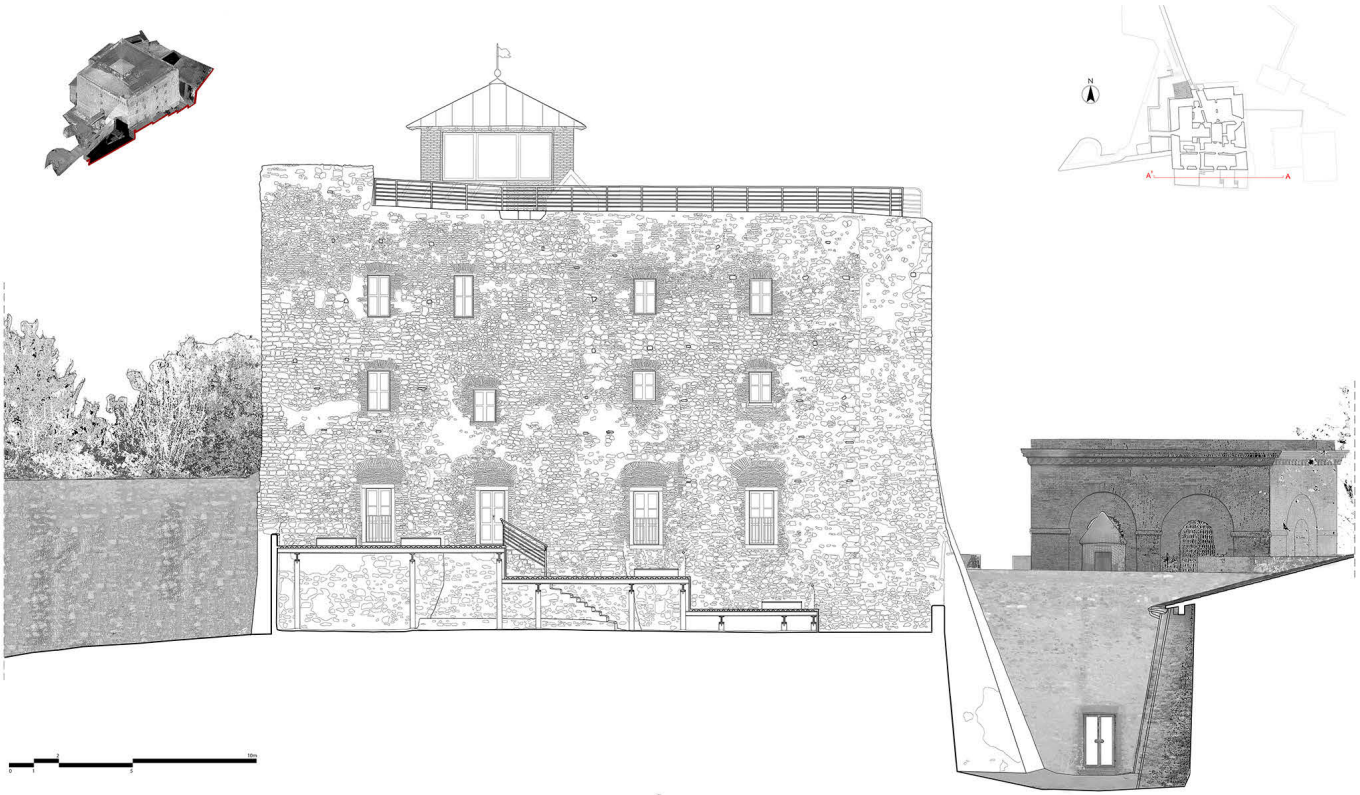


Fig. 8 - Photogrammetric survey of one of Piombino's military buildings.

Fig. 9 - Wireframe graphic rendering of an external elevation of the Cassero.

transformations have profoundly altered the image of the architecture to such an extent that it is unable to trace the lines on the map of the Madrid Code to those of the modern architectural survey.
To solve this problem it was therefore necessary to deepen as much as possible the evolutionary history of Piombino fortifications. In order to reconstruct the image of these architectures over time, a thorough historical analysis was first conducted, based on the existing bibliography[6] and historical documentary sources available in the archives. At the same time, a search for iconographic sources was carried out to depict the city and its main fortifications over time.
To be able to adequately understand the importance and innovative scope of Leonardo da Vinci's project, it was necessary to frame his work as a military architect within the cultural panorama offered by the courts of the late fifteenth century. If the work of Leonardo the architect has been thoroughly investigated over the years, comparing the representation and evolution of the forms of the fortifications in the different periods of his life, it is however true that the texts and drawings present in his notes derive most of the from the study of other authors, first of all Francesco di Giorgio Martini. From these engineers who worked in the main Italian courts, Leonardo had certainly received important technical and architectural knowledge; Leonardo's fortified architectural drawings cannot be studied without knowing the war requirements of the period: how the fortresses were defended and by which siege weapons they were hit. Leonardo presents himself to the scholar as a student who in the pages of the Madrid codex annotates sentences from Martini's treatise on civil and military architecture, of which among other things he owned one of the first manuscript editions [Mussini 1991]. The study of contemporary

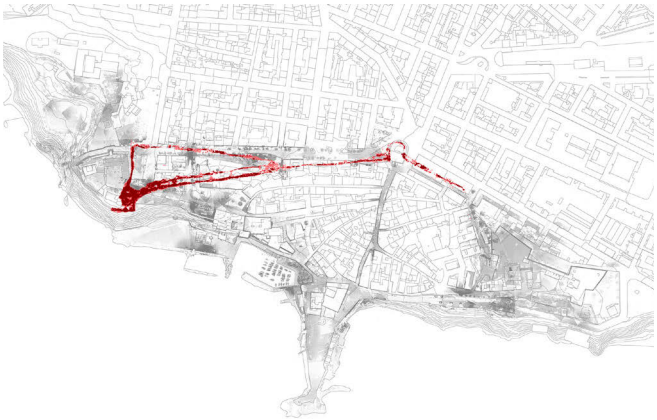
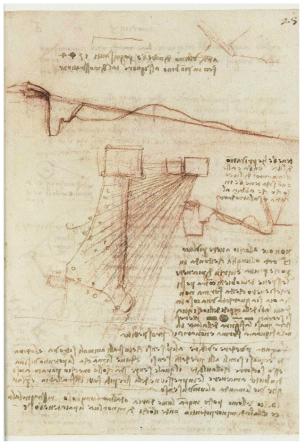


Fig. 10 - Graphic rendering with photographic ortho-image of a longitudinal section of the Rivellino of the Porta di Terra.

Fig. 11 - Planimetric alignments between Leonardo da Vinci's drawing and the current state drawing.

Fig. 12 - Example sheet made for each page of the Madrid Code II concerning the interventions on Piombino.

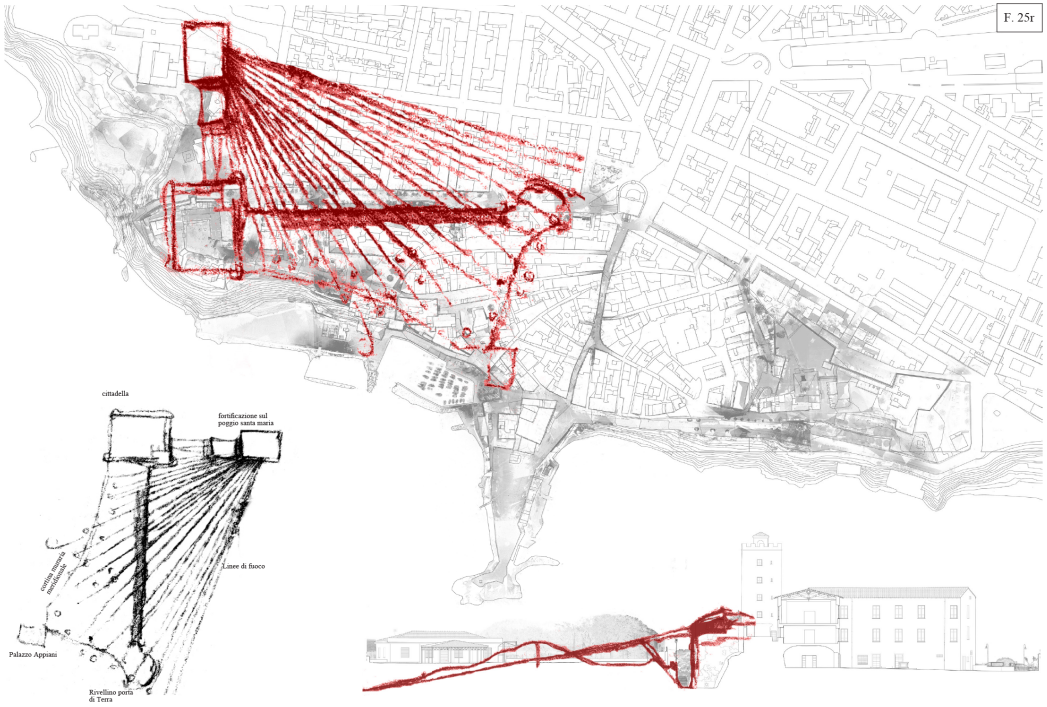


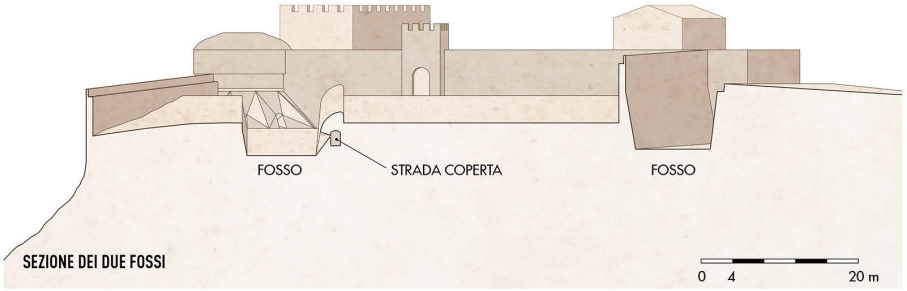
Addì ultimo di novenbre per Ognisanti 1504 feci in Piombino al signore tale dimosstratione.

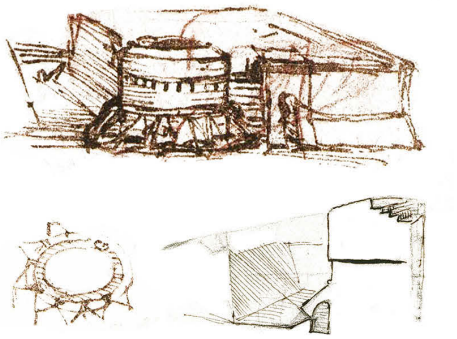
Tenebre è privation di luce. Ombra è alleviamento di luce. E non si dà tenebre in loco che abbia alcuna esalation d'aria

No' noce all'ochio avere più luce quadrata o llunga che ttonda, inperochè per utta e in [vi]rtù di ricevere le sspetie delli obiatti contraposti. E che sie vero che tta[l] forma non dia [n]oia, sia guardata una cosa infra lli labri delli coperchi delli ochi quasi serrati, che resisterà quasi la figura della luce in nella figurata forma e non varia i' prospettiva.

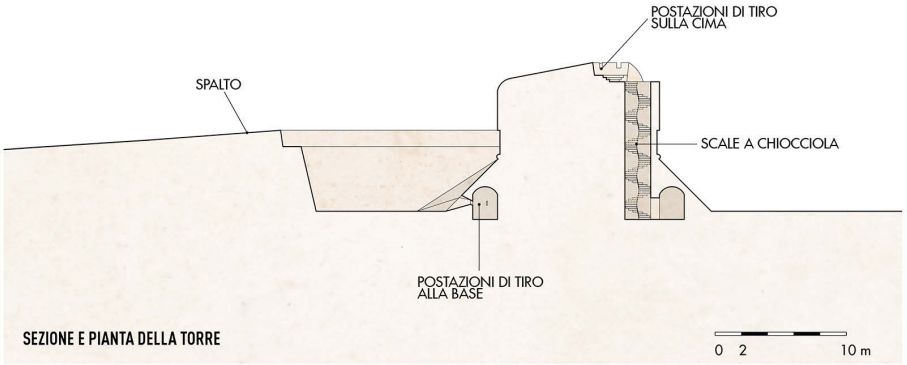
La gatta per vedere e uldire ha lo primi sensi che infra lli animali si trova. E ll'odorato è equasi simili alli predetti sensi. E dove li manca la potentia visiva, essa socorre con l'auldito, il qiale sempre sta collo orechio parato, a uso d'inbuto, a ricevere le inpressione delli stragiti fatti infra ll'aria, e per larghe vie li manfa al comun senso.
L'ochio dell'omo posto in gran lume d'aria o d'altro luminoso, risstringe la luce e lla fa di minor potentiam inde i lochi di minor luce li paian tenebrosi

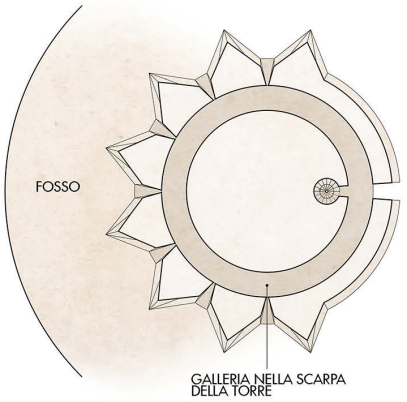


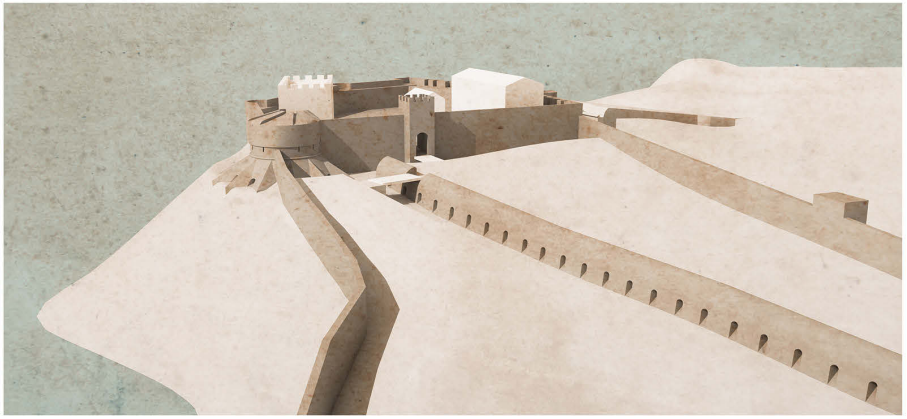




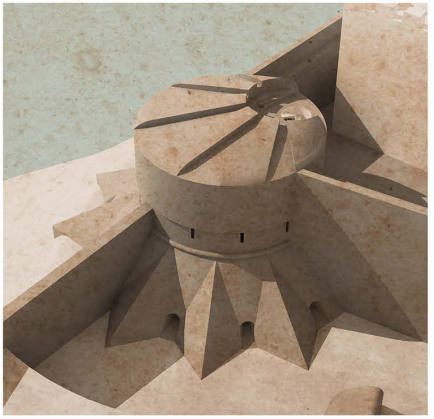
Schizzi relativi alla torre nel Codice di Madrid II (ff. 37r, 85v)







Ricostruzione del progetto di difesa sul fronte della Cittadella che guarda verso la città



Ricostruzione 3D della torre progettata da Leonardo

authors could therefore be the key to perfecting and understanding the form that Leonardo intended for his architecture, in line with the war requirements of the period.

Obtained results and developments

From the integrated comparison of the notions acquired as expressed in the previous paragraphs, it was possible to conduct an in depth study concerning Leonardo's drawings and the fortified architectures of Piombino. Numerous new drawings have been identified that represent architectures or schemes concerning the defenses of the city, while many pages that had already been attributed to the project, or in a generic way without deepening their meaning or, sometimes, erroneously, have been adequately revised and corrected. The analysis of the representations made by Leonardo da Vinci allowed us to fully understand the design method; this was possible thanks to the direct comparison between accurate surveys of the actual state of the fortified architectures and their surroundings: specifically, it was possible to understand that many of the drawings in the Madrid code represented the actual state of the places. As a designer, Leonardo first had to clash with the study of the site and pinned on his sheets numerous representations of the architectural and urban survey of the fortification system that he had to modernize. In the case of the Citadel of Piombino these surveys even contain the measurements of the angles and distances measured directly in the field when tracing the polygons: the verification between the data measured in 1504 and the results of the digital survey leaves no doubt as the polygons overlap exactly with what remains of the fortified structures. Subsequently Leonardo began to draw up various design options that would heal the defensive problems of the perimeter by fortifying, systematizing the structures of the Citadel, the ravelin and the keep. Furthermore, for each of these fortifications the project has been deepened on the architectural scale, with drawings that propose various interventions aimed at improving the firepower and defense of the existing structures.

Thanks to the digital survey it was also possible to interpret which of these projects was actually carried out, discovering that probably a part of Leonardo's structures still exist, others could, thanks to a coordinated effort that unites territorial management bodies and universities, be brought to light with adequate archaeological excavations: unfortunately, in fact, the construction events of the last century have led to the destruction of most of the city walls, the filling of the ditches of the fortifications and the burial of struts and other structures no longer immediately visible to the visitor's eye.

The research project made it possible to fully understand the meaning of many of Leonardo da Vinci's drawings; the challenge within research and the disciplines of representation consists in finding the right method of transmitting information even for a public not educated in understanding Renaissance and technical drawings. For this reason it will be interesting to use three-dimensional modeling techniques to give shape to the military architecture of Piombino at the end of the fifteenth century, reconstructing the stages of evolution of the medieval castle, paying particular attention to the Renaissance modifications. Specific insights will be made for each architecture of the fortified circuit and the history, development over the centuries and the link with Leonardo's intervention will be shown. The

Fig. 13 - Reconstruction of the Leonardian project of a tower for the Citadel.

reconstruction of the three-dimensional model will be an interesting tool for presenting Leonardo da Vinci's work in Piombino, using the research carried out on the interpretation of the drawings and texts of the Madrid code for the virtual reconstruction of the reliefs, design intentions and achievements. Such a popularizing tool would allow the circulation of technical notions related to military architecture and engineering even to a public of "non-technicians", presenting what is the best documented example, at least in the early stages of conception, of a military project and urban executed by Leonardo da Vinci.

Notes

1. The bibliography on Leonardo's studies is vast, and has been revisited several times; for a recent historiography from which to go back to the specialized texts, see Vecce C. (2021). *La Biblioteca di Leonardo*. Giunti, Firenze.

2. For a report on the formation of Leonardo's military architecture, see a paper written together with prof. Bertocci entitled Leonardo's education as a military architect.

3. For a summary of the studies on the Piombino project see Bertocci, Bigongiari 2020.

4. In this regard, the documentation projects of the architecture drawn in the Paris Manuscript B [Vaienti et al. 2020] and the reconstruction of the lantern project of the Milan Cathedral [Frommel et al. 2020].

5. A project that exploits similar bases but with informative purposes was undertaken on the documentation of the architectural drawings of Francesco di Giorgio Martini [Nanetti et al. 2020).

6. The most recent bibliography on the history of the fortifications of the city of Piombino can be consulted in Bigongiari 2020.

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03 INTELLIGENT MODELS? STRATEGIES AND ISSUES IN THE DIGITAL SUPPLY CHAIN FOR ARCHITECTURAL HERITAGE

Ramona Quattrini

Abstract

The article attempts to outline a significant path in the development of HBIM processes, in which authoring tools play a secondary role, while the main goal is the definition of a modelling strategy for the existing monumental heritage. Through 4 case studies, developed since 2014 and testifying a line of research in which the focus is on the management and incorporation of significant forms of intelligence for the preservation of the heritage itself, a theoretical reflection on the deep meaning of modelling today and with the discipline tools of Drawing is articulated.

The case studies have been selected to cover a wide range of themes and issues that are particularly compelling when dealing with Heritage BIM: from decay analysis with various LODs and grades, to stratigraphic analysis, to evaluation of structural behaviour with finite element modelling. Strengths and weaknesses of the experiences carried out are highlighted and an emerging theme such as artificial intelligence applied to cultural heritage is explored. In the latter area, the potential of HBIM models for training deep neural networks is discussed.

L'articolo delinea un significativo percorso nello sviluppo di processi HBIM, in cui gli strumenti di *authoring* giocano un ruolo secondario, mentre l'obiettivo principale è la definizione di una strategia di modellazione per il patrimonio monumentale esistente. Attraverso 4 casi studio, sviluppati a partire dal 2014 e che testimoniano una linea di ricerca in cui il focus è costituito dalla gestione e incorporazione di forme di intelligenza significative per la conservazione del bene stesso, si articola una riflessione teorica sul senso della modellazione oggi e con gli strumenti disciplinari del Disegno.

I casi di studio sono stati selezionati per coprire un'ampia gamma di temi e problematiche particolarmente cogenti quando ci si occupa di Heritage BIM: dalla analisi del degrado con vari *LOD* e *grade*, alla analisi stratigrafica, alla valutazione del comportamento strutturale attraverso la modellazione ad elementi finiti. Si evidenziano punti di forza e di debolezza delle esperienze condotte e si approfondisce un tema emergente come quello dell'intelligenza artificiale applicata ai beni culturali. In questo ultimo settore viene trattato il potenziale dei modelli HBIM per l'istruzione di reti neurali profonde.

Introduction

Considering the huge quantity of data that nowadays can be easily collected in survey campaigns of architectural heritage as well as the potentials of digitization and modelling techniques, it is observed a crucial step in the processes of Built Heritage knowledge, conservation and management. Given that the current practices of multi-scalar acquisition are very robust and efficient, a reflection must be carried out on interdisciplinary research, standing on representation discipline, that has the strength to be a dialogue tool between the new trends of Heritage Building Information Modelling (HBIM) and/or Artificial Intelligence (AI) with the most compulsory needs of our heritage. In this light the paper tries to reply to a research question: "Is it possible to build up intelligent models?".
Questioning intelligent models means emphasising not the tools but the objectives, when a research deals with Heritage it is very important not to focus on software or cutting-edge technologies but in the motivations of the research, that lie in the needs of Cultural Heritage. In this field, ScanToBIM processes, HBIM workflows and AI applications are enabling new forms of digital data management as well as new digital assets from existing ones, with a surprising capacity of mimesis. However, a theoretical debate on the implications of such technologies in the context of Digital Humanities and Computational Modelling is still lacking.
What are the meaning and the goals for which a model is constructed? What are the research outcomes? According to Riccardo Florio [Florio 2020], "the action of drawing as a complex operation of transposition of the different realities, factual or prefigured, insists significantly on the continuing transcriptional action in which the necessary hermeneut of the cognitive aspects is imposed in order to supervise the continuous passages between the pre-figurative and its restitution". The approach here proposed tries to highlight and to understand how much of the skills useful in architecture analysing and modelling can be made available to the "machine", with the goal to accelerate cognitive or management processes with regard to the built heritage. Some HBIM models, considered as an existing digital heritage, were used to obtain the semantic intelligence, their construction and process of generation is studied focusing on choices and selection of information, mainly about the ontologies that constitute the skeleton of the model. This process implies the systematization of a knowledge in which the modelling action is a knowledge itself. From this specialised intelligence comes a cyclical path which transforms this knowledge into new forms of collective intelligence, for the heritage benefits.

State of art

The large spreading of point clouds for architectural heritage documentation, based on terrestrial laser scanning (TLS) or photogrammetric surveys, results in the availability of more accurate highly descriptive discrete databases. In parallel the new paradigm of Building Information Modelling boosted the requirement of informed and structured representations, founded on intelligent semantic subdivision. Many studies have focused on the possibility of entering survey data in BIM management platforms, achieving very important results in ScanToBIM, as recently testified by surveys such as [López et al. 2018) and also pursued by the author [Moreira et al. 2018] . To date, the most promising research topics in the context of a digital transformation of built heritage and related to the approach proposed in this project are briefly summarized in the following points:
a) the modelling of knowledge and construction features, with particular reference to the Level of Knowledge (LOK) also in the definition of Heritage Building Information Repository (HBIR) [Castellano-Román, Pinto-Puerto 2019];
b) the need to create reliable interfaces for the connection of HBIM and databases to define procedures also outside

authoring software, such as for the INCEPTION project [Iadanza et al. 2019] and for the BIM3DSG platform [Rechichi et al. 2016]; c) the definition of ontologies and semantic structures shared and useful for heritage as in [Acierno et al. 2017].
In addition to the huge literature in HBIM processes, it is important to remind attempts to automate, at least partially, the ScanToBIM process, which can be surely helped by AI approaches, as testified [Achille et al. 2020; Malinverni et al. 2019].

A first HBIM to semantic web tools: Santa Maria of Portonovo

The work carried out on the church of Santa Maria at Portonovo starts with a high quality TLS survey and a first attempt [Quattrini et al. 2015] to demonstrate the feasibility of a whole BIM approach for complex architectural shapes starting from point clouds. A novelty of the method was to work in 3D environment along the process, verifying and assessing quality of geometrical results and critically

Fig. 1 - Survey data of Santa Maria of Portonovo: the TLS point cloud in several views.

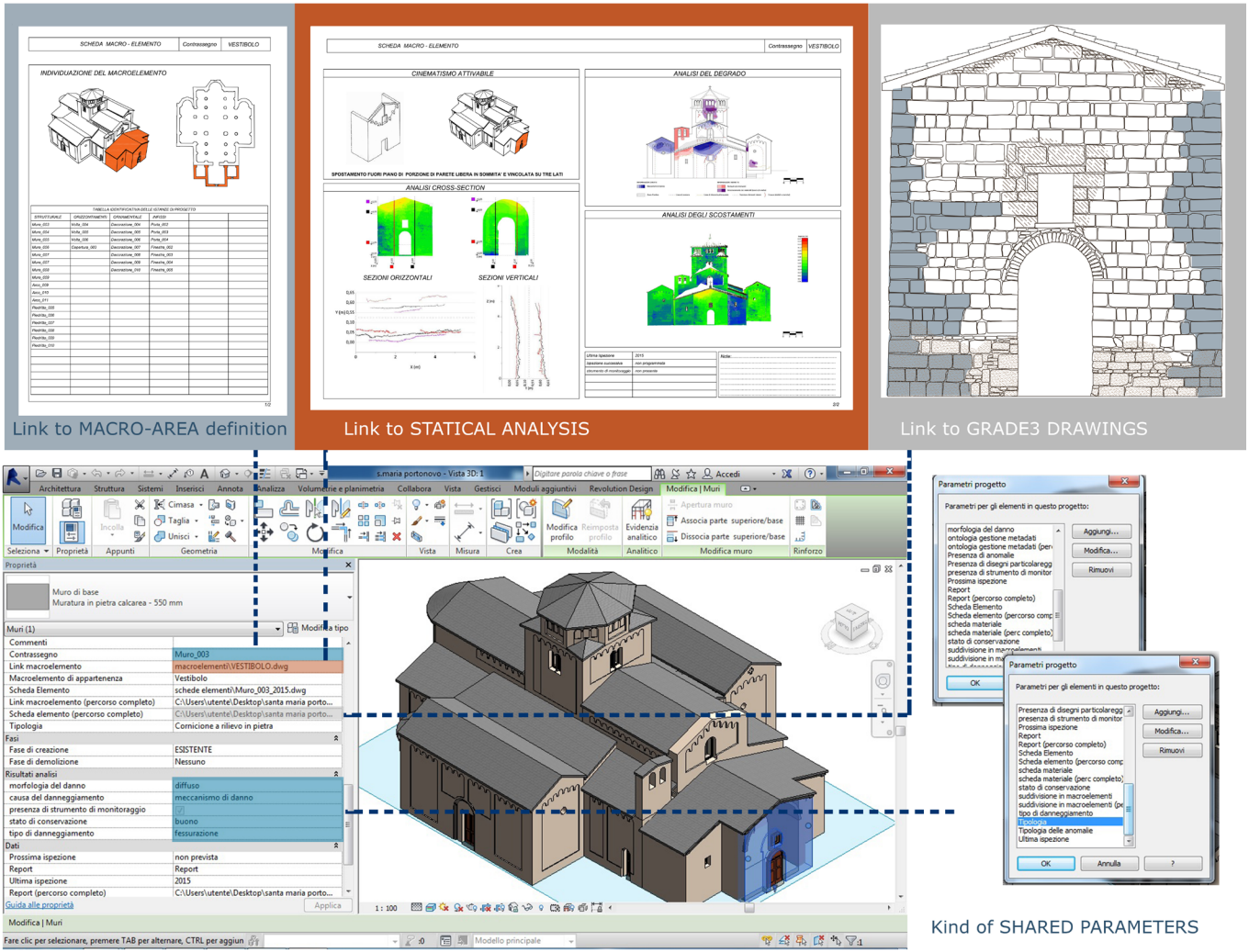
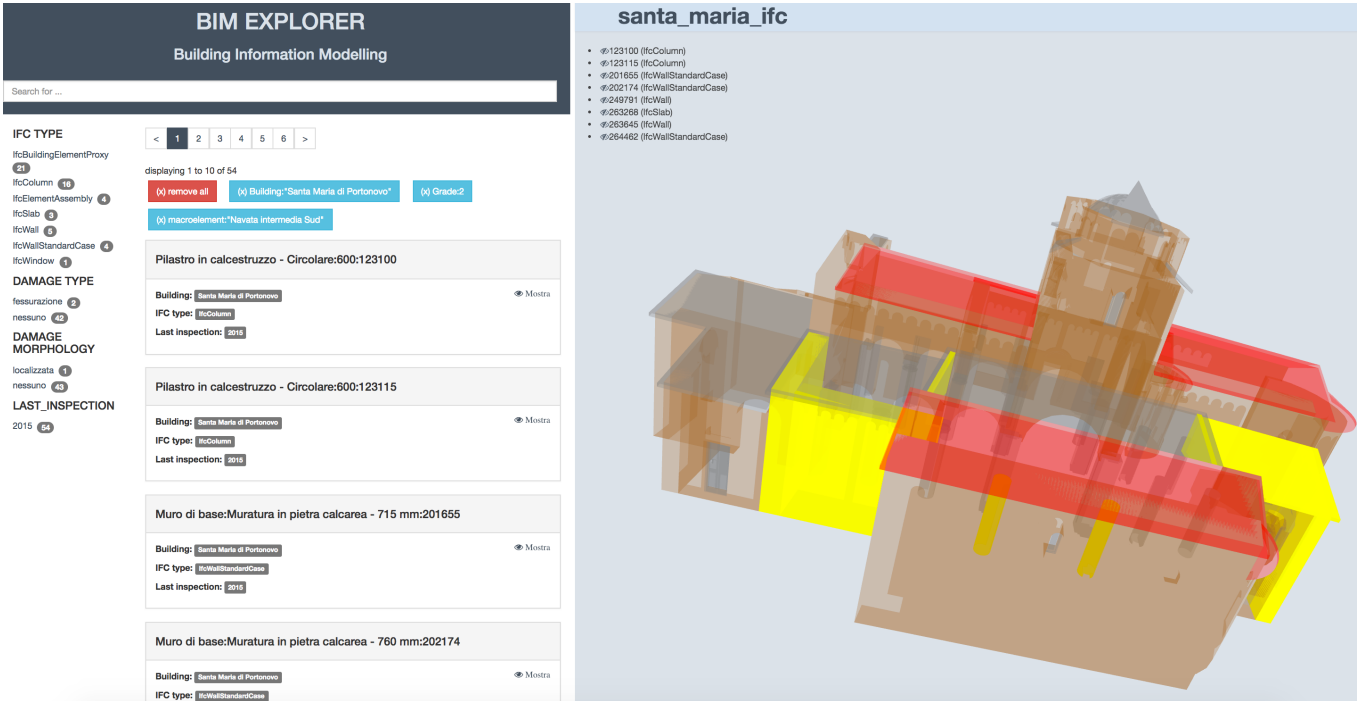


Fig. 2 - The HBIM data enrichment of Santa Maria of Portonovo, different data and analysis were linked to model.

Fig. 3 - The BIM explorer demo, carried out in collaboration with Department of Information Engineering.



discussing the obtained LOD (figs. 1, 2).
The first modelling results facilitated then a quite novel approach to solve HBIM oriented interoperability issue, by developing and testing a workflow that exploits semantic-web technologies. It was obtained that the user queries a repository composed of semantically structured and HBIM data rich in terms of conservation and restoration purposes. The pipeline dealt with: (i) modeling an ontology with the main information needed for the domain of interest, providing a data structure that can be leveraged to inform the data-enrichment phase (ii) creating a set of shared parameters (iii) structuring data in a machine-readable format (iv) As a final step, a demonstrative data exploration web application was based on the faceted browsing paradigm (fig. 3) and allowed to exploit both structured metadata and 3D visualization [Quattrini et al. 2017].

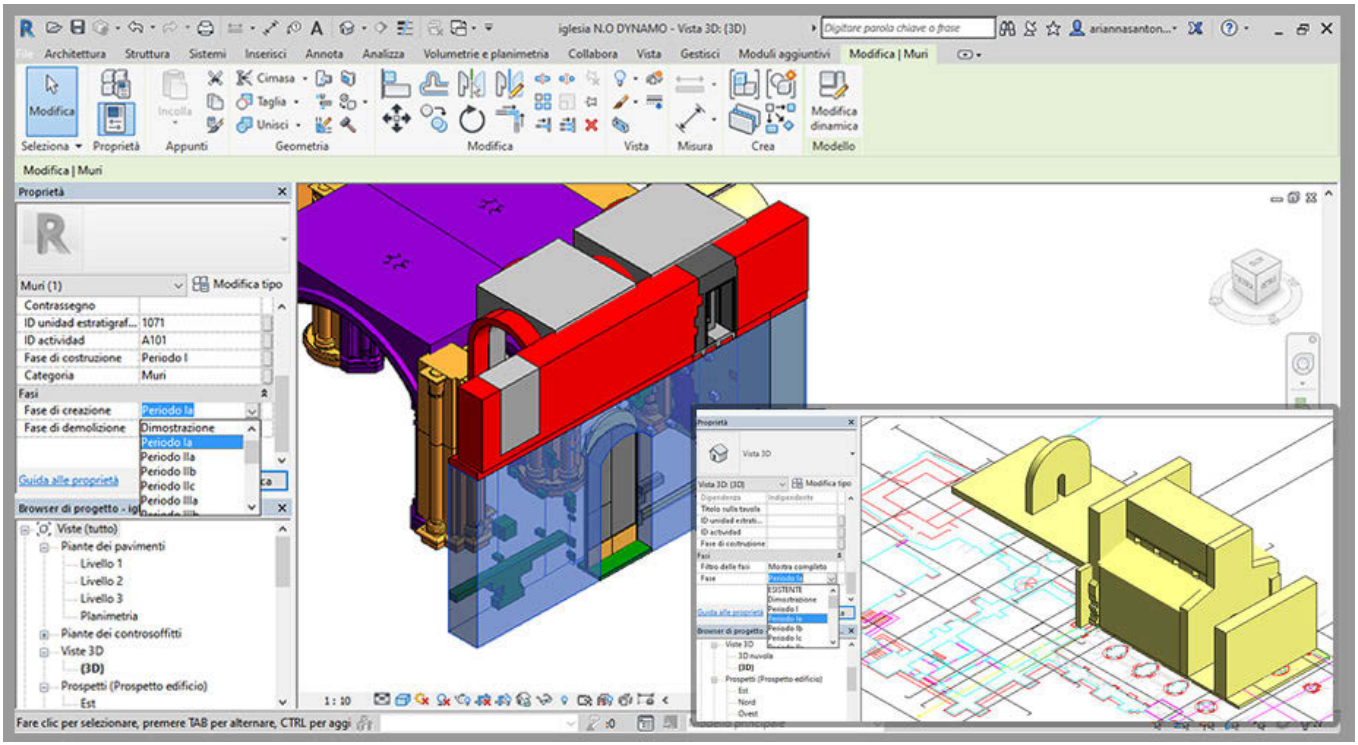
An HBIM for mapping archaeology of architecture: the Real Colegiata of San Isidoro in León

The research started from the observation of some lacks in HBIM workflows when considering specific features, such as the materials and construction techniques and, in the other, the temporal dimension. Regarding the constructive issue, it must be pointed out that historical buildings include materials and construction techniques which were typical from the historical periods and no standardized elements were used, so that each element, should be considered as unique. In addition, the temporal dimension must be taken into account, given that historical buildings are the product of a set of constructions and destructions that take place

throughout the whole life of the building. It is essential to include both the constructive issues and the transformation sequence when developing an HBIM model, given that those features involve both the 3D model creation, and the design and setting of an information system ontology. Accordingly, the transformation sequence offers, perhaps, the most adequate organization for the structure of such a database, allowing a coherent relationship of the information with the nature of the historical building.

The case study, the Real Colegiata of San Isidoro in León, has been developed in an international research team between Italy and Spain[1]. The research dealt with the creation of a HBIM model taking into consideration the specific features of historical buildings, especially the constructive and temporal issues [discussed in detail in Santoni et al. 2021]. The main developed steps were: i) a high complexity model has been created analysing the modelling strategies and reaching a high level of division (figs. 4, 5); ii) a new knowledge-based taxonomy and data enrichment for HBIM environment, enabling to incorporate knowledge about temporal sequences and constructive aspects; iii) a system for customized queries to the information system via VPL[2], exploring the constructive configuration and the temporal sequence through Dynamo tool (fig. 6).

The results seem also interesting in the light of cross-fertilization and technology transfer to the professional scenario, as testified by the Digital&BIM 2020 award[3].



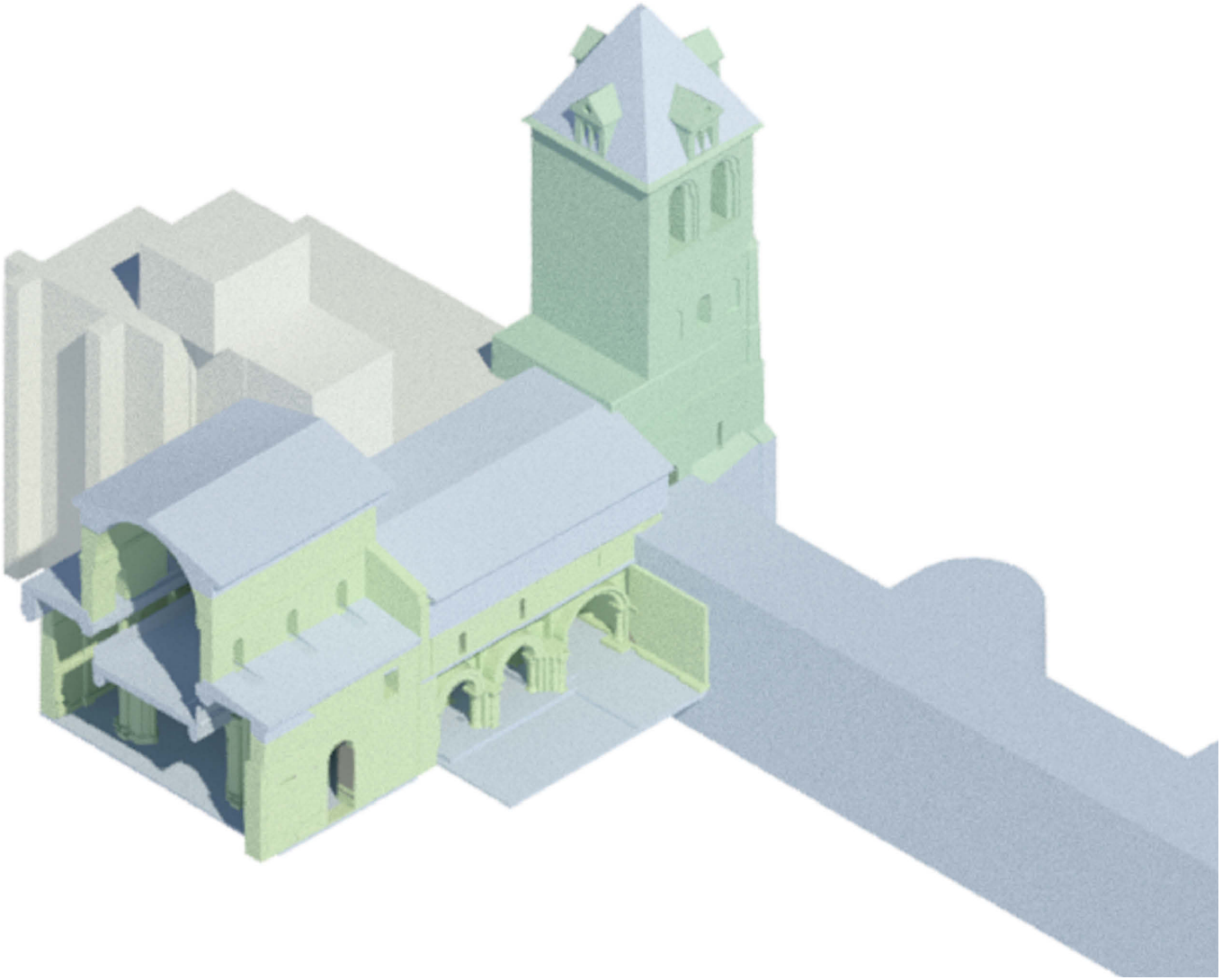


Fig. 4 - Implementation of historical phases of building on the case study of Real Colegiata of San Isidoro in León.

Fig. 5 - The constructive intelligence of the HBIM model, exemplification of different level of subdivision in the case study of Real Colegiata of San Isidoro in León.

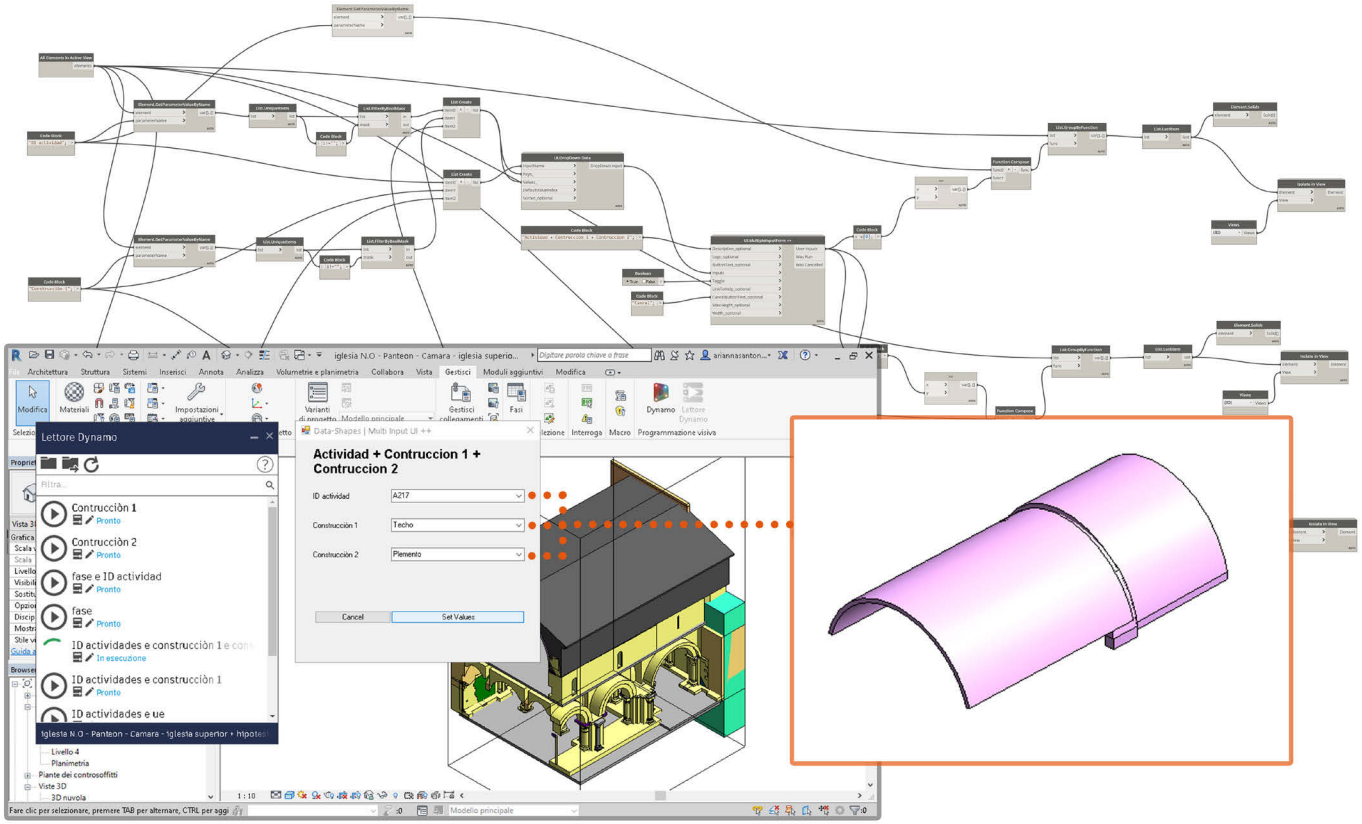


Fig. 6 - An example of customized query through Dynamo tool: exploring the HBIM model of Real Colegiata of San Isidoro in León.

Fig. 7 - 3D textured model of San Cyriacus' Bell Tower: a) axonometric view; b) split axonometric view.

From TLS to structural behaviour intelligence: San Cyriacus' Bell Tower

The work belongs to two disciplinary fields with specific workflows and aims to automate the transformation from reality-based digital facsimiles to Finite Element Analysis. The research theme is framed in historical artefacts survey targeted to structural analysis and assessment. A specific case study which allowed a gradual process of workflow optimization was selected. The workflow was instantiated on bell towers, which have proved to be particularly vulnerable under earthquake both for their complex geometries and for their inadequate state of conservation. The first attempts [Quattrini et al. 2019], mainly expensive and limiting, were improved in order to achieve a streamlined and fairly performing workflow.

The relevance of the topic is supported from the consideration that evaluation and assessment of new workflows aimed at creating structural analysis solidly based on the point cloud are needed, in order to implement intelligent and convenient modelling strategies.

The work started from the analysis of some similar approaches, it highlights their partial results and then proposes a methodology to semi-automatically transform the point cloud into a 3D FEM. In order to demonstrate usability and reliability of similar models in the structural field, the case study of the bell tower of the cathedral of San Ciriaco in Ancona (fig. 7) was also used to perform a numerical updating based on Operational Modal Analysis (OMA).

Improvements in the workflow were achieved thanks to the severe reduction of the steps subject to the operator's discretion, thanks to the introduction of retopology. Thanks to the latter, a more efficient workflow (fig. 8) was obtained, in which a) computational times have been significantly reduced; b) high Level of Detail, according to the historical architecture features, was managed.

Deep learning techniques from/to Scan2HBIM: the Ducal Palace in Urbino

This case study presents an experiment dealing with the segmentation of point clouds and the facilitation of ScanToHBIM approaches, made possible by the large amount of data acquired on the Ducal Palace of Urbino. The digitisation phase of the building and museum artefacts is a fundamental step of the CIVITAS project. The point clouds, with the various gathered accuracies (fig. 9), constitute a high-quality morphometric

model, but the pertinence of the single points to the architectural parts and mouldings is usually selected by skilled operators. The possibilities opened by AI approaches lead to new research perspectives, in order to find and test suitable workflows to recognise points and assign them a semantics consistent with the rules of the architecture.
A crucial theoretical step is the classes discussion, refinement and final identification. Following an analysis of coherence with the existing and consolidated thesauri and considering the morphology of Renaissance age architecture and the features of the acquired data, a first level scale of the semantic hierarchy was chosen (fig. 10).
Moreover, considering that the current main challenge in Deep Learning approaches applied to cultural heritage is the absence of sufficiently large, annotated data sets, useful for the networks training, the presented approach tried to reveal a semantic intelligence in previously carried out models. Thus, the approach benefits of some models of Palladian villas, built up for the CISA project "Palladio Library", as well as of most recent HBIM models, i.e.: Palazzo Ferretti, Santa Maria di Portonovo and Palazzo Ducale. Their main advantages lie in their semantic structures, vocabularies and ontologies.
In addition, parametric models present on the web were used and appropriately selected. In this way, a sufficiently large data set of synthetic clouds is obtained and assessed to train the neural network. This phase therefore places drawing expertise on stage and the intelligence in the models is regenerated and acquires new life and unexpected opportunities for boosting opportunities in DCH.
The shapes grammar incorporated in all the chosen models, with the constituent ontologies, is the main feeding of the neural network and it was automatically obtained. In fact in the models, the classes were also consistent with those of the point clouds that we would like to segment, both in terms of formal qualities and hierarchical articulation. All models were stored in the various formats which contained the taxonomy. At this point, the workflow for the Deep Learning approach foresees firstly the training of the neural network and then the experimentation on a never observed dataset. The DGCNN network was chosen and also its refinement (RaDGCNN) see [Morbidoni et al. 2020].
Two experiments were performed on two different case studies: in the first one, we used the TLS point cloud of the courtyard of the Ducal Palace of Urbino to evaluate the trained models, trying to identify 8 different classes of architectural elements. In the second, the models trained were evaluated on the TLS point cloud of Palazzo Ferretti about 6 different classes. The results allow us to conclude so far that the use of synthetic data can be effective in the automatic segmentation of TLS point clouds. Of course, this is only a first step and an encouraging scenario to be explored and analysed with other applications to support the ScanToBIM process of historic buildings.

Conclusions

The article has outlined a significant path in the development of HBIM processes, in which authoring tools play a secondary role, while the main goal is the definition of a modelling strategy for the monumental heritage. Through 4 case studies, developed since 2014 and testifying a line of research in which the focus is on the management and incorporation of significant forms of intelligence for the preservation of the heritage itself, a theoretical reflection on the deep meaning of modelling today and with the discipline tools of Drawing is articulated. The case studies have been selected to cover a wide range of themes and issues that are particularly compelling when dealing with Heritage BIM: from decay analysis with

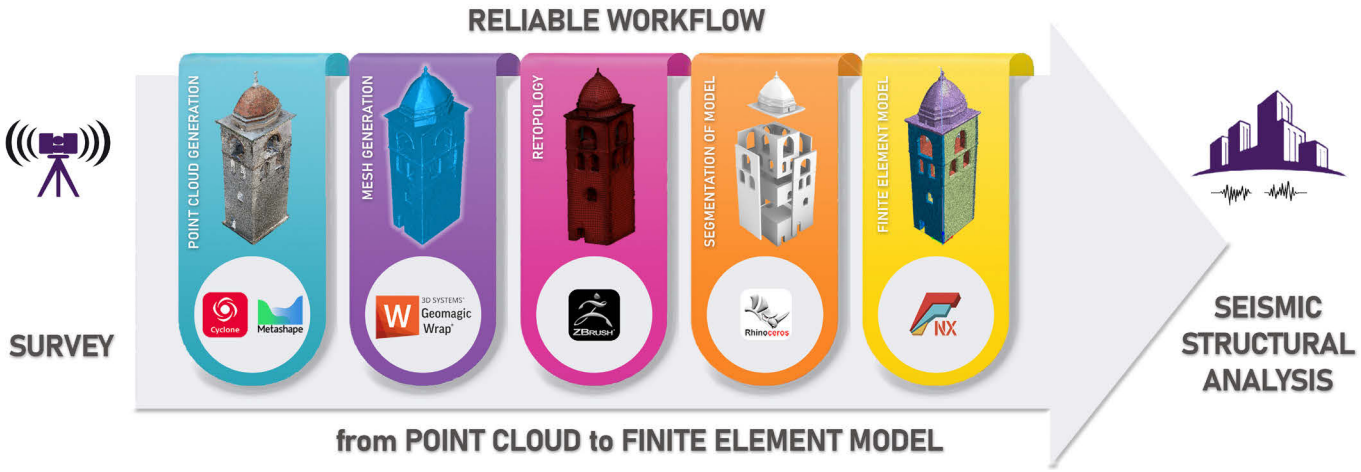


Fig. 8 - The workflow carried out and assessed for the management of data from TLS to structural behaviour modelling.

Fig. 9 - Point cloud of the Ducal Palace in Urbino.

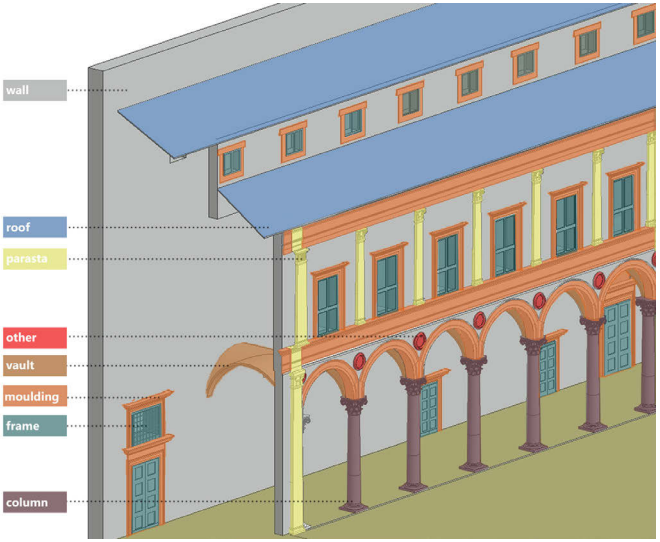


Fig. 10 - Identification of classes in the taxonomy about the Honour Courtyard of Ducal Palace in Urbino.

various LODs and grades, to stratigraphic analysis, to evaluation of structural behaviour with finite element modelling.
Considering the definition of collective intelligence by Pierre Levy as a "form of universally distributed intelligence, constantly enhanced, coordinated in real time, and resulting in the effective mobilitation of skills", we can conclude this reflection with an invitation to take advantage from the intelligent models to share a new effective heritage communities intelligence.

Notes

1. The work was carried out by Arianna Santoni, during an international traineeship at the Polytechnic University of Madrid under the supervision of Ramona Quattrini (Polytechnic University of Marche) and Rafael Martìn Talaverano, the company Urbe Pro Orbe also collaborated in the person of José Ignacio Murillo-Fragero. The funding is Campusworld.

2. This development has been performed under the supervision of Professor Carlo Battini, University of Genova.

3. The project "HBIM of the Real Collegiata of San Isidoro in León: new strategies for 4D and constructive intelligence" has been awarded by the third place at the DIGITAL&BIM 2020 AWARD – category Digital technologies for the construction process.

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04 DOCUMENTATION AND DIGITAL REPRESENTATION SYSTEMS FROM THE MONUMENT TO THE TERRITORY: THE H2020 PROMETHEUS PROJECT

Raffaella De Marco, Anna Dell'Amnico

Abstract

The H2020-RISE-PROMETHEUS project, coordinated by the University of Pavia, aims to define a multiscalar information system to enhance the widespread architectural heritage of the European Cultural Heritage Routes, starting from the case study of the Upper Kama territory (Russia).

The international collaboration between universities and companies initiates an optimization of infographic languages and expresses them in a single information modeling protocol, structured on a process of morphological, technological, and typological semantization, from the territorial level to the architectural scale, for the combined management of historical memory, information, and intervention on the monumental site.

Il progetto H2020-RISE-PROMETHEUS, coordinato dall'Università degli Studi di Pavia, vuole definire un sistema informativo multiscalare per la valorizzazione del patrimonio architettonico diffuso delle European Cultural Heritage Routes, a partire dal caso studio del territorio dell'Upper Kama (Russia).

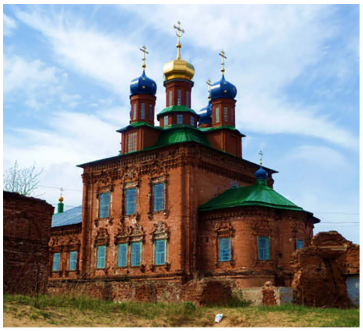
La collaborazione internazionale tra Università e imprese avvia un'ottimizzazione di linguaggi infografici e li esplicita in un unico protocollo di modellazione informativa, strutturato sulla base di un processo di semantizzazione morfologica, tecnologica e tipologica, dal livello territoriale alla scala architettonica, per la gestione combinata di memoria storica, informazione e intervento sull'opera.

Introduction[1]

The multi-scale knowledge of Cultural Heritage and its connection between territory, architecture and community, introduces a scientific reflection on its methods of documentation and communication, which are increasingly required to be assessed between research fields across Tangible and Intangible Heritage[2]. Built Heritage and its monuments assume the role of physical expressions of wider cultural basins, functioning as visible and stratified collectors of those characteristics and identity values that represent local communities and their specific history[3].

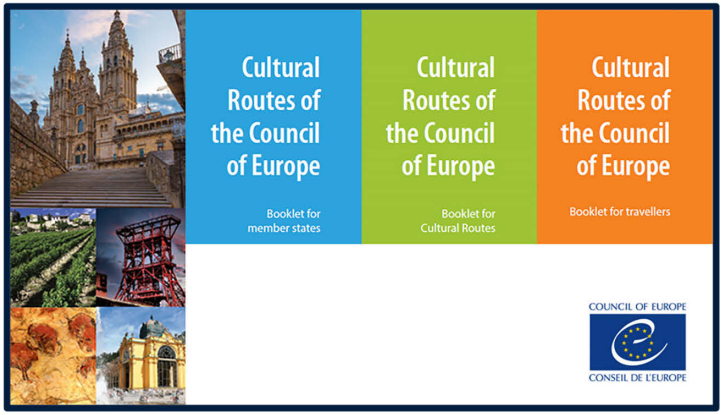
In recent years, the European Community has emphasized the values of 'territorial inclusiveness' and 'widespread Heritage', with a renewed interest in the recognition of Cultural Routes[4]. The classification of Cultural Heritage Routes has been encouraged towards management and enhancement programs across political boundaries, leading to the identification of wide cultural basins across Europe[5]. In these basins, an architectural Heritage interested in unique cultural and typological phenomena has been always found.

The necessity of a unified management protocol highlights, as methodological input, the recognition of features and values of connection between physically distant but culturally joint sites, supported by "tangible elements that bear witness to their cultural heritage and provide a physical confirmation of their existence"[6]. Geographical boundaries help to shape Cultural Heritage Routes,







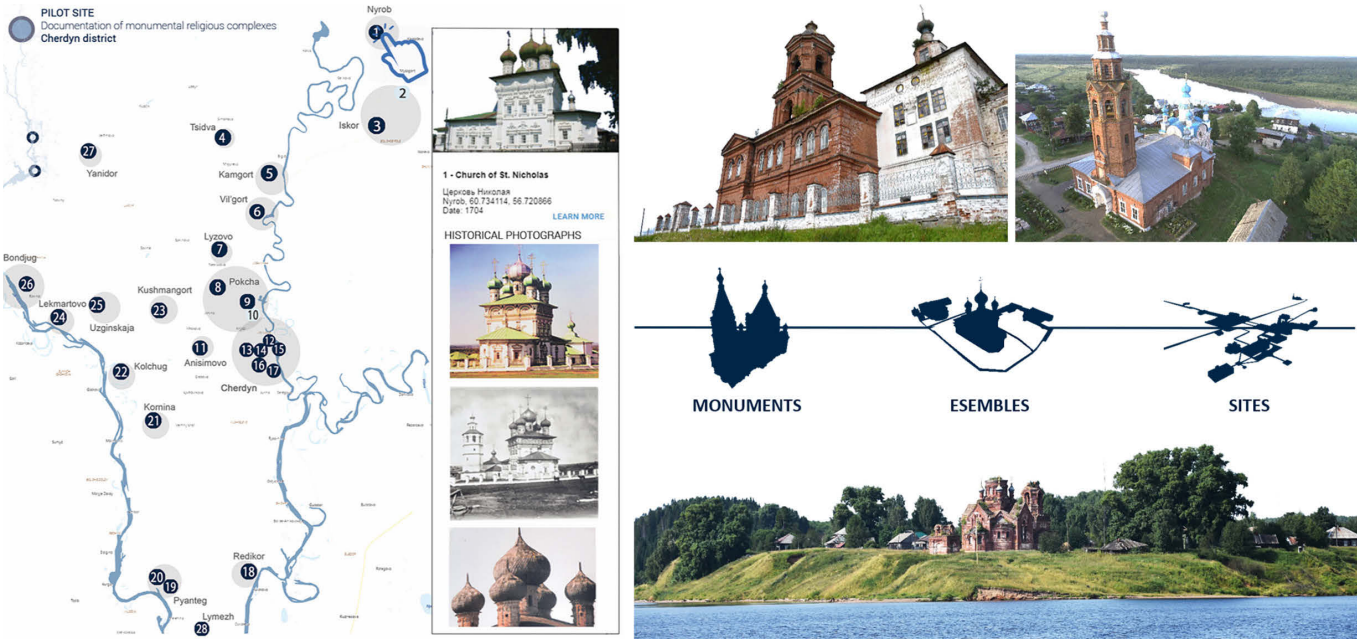


Fig. 1 - Selection of main historical, artistic, architectural, artcraft and traditional characters of Upper Kama Cultural Heritage (Russia, Perm krai) considered in the framework of material and immaterial values recognized for Cultural Heritage Routes.

Fig. 2 - The identification of architectural sites along the Kama Route and the recognition of multiscale dimensions of its Heritage, from the building to the landscape, has defined the preliminary task of the documentation project within integrated procedures of scanning and photographic mapping.

determining their path or their development over time, but they cannot limit their cultural phenomenon, which requires to be assimilated in the methodology of analysis and synthesis of the typological contexts.
The recognition of inclusive categories for architectural features in Cultural Heritage Routes, associated in conformity of constructive elements, technological units and typological modules, recognizes a "joint system which enhances their significance". This analysis guides the structure of digital archives, managed as "libraries", for the report of constructive common characters of architectural Heritage along the Routes.

Within this framework, the H2020 PROMETHEUS project aims to define and manage Cultural Heritage Route's digital archives considering the opportunities of Information Systems, where geometric "shells", as 3D parametric models, can be implemented through a reliable and dynamic informative content, structured on query data and descriptors.
'Digital Drawing' finds concrete application as 'Information Modelling', developing a grammar of shapes based on the identification of variants and invariants of constructive and territorial features, which define elements and an architectural language useful to communicate the heritage of the Route and to support its management and maintenance (fig. 1).

The case study, set on a border basin between Europe and Russia, adopts the Upper Kama area as a context for verifying the strategy of digitization on the features of the Cultural Heritage Route, and its advances for the systematization of an international research protocol.
The Upper Kama region, in the Kama River basin, developed as a commercial and cultural crossroad between the 15th-18th centuries, with the first industrial settlements, till the rapid decline with the Revolution (1917). The development of monumental Orthodox complexes attracted continental architects and artists to define a new and dominant architectural profile in the river landscape. The territorial phenomena led to the spread of numerous urban centres and to the dispersion of their monumental sites, associated in districts but assigned to a fragmented territorial administration[7].
The definition of an Information Modelling Library on Upper Kama heritage becomes a necessary phase and a fundamental input, in virtue of the constructive and material richness found in its architectural sites, for the launch of a methodological and archival protocol towards the extension of Digitation Programs on European Heritage[8]. Parametric models and digital devices of representation are suggested to provide a centralized global context to information stored therein, and to be effective tools of knowledge archival for the valorisation of the Cultural Heritage Route (fig. 2).

Census digital flowcharts for technical interoperability and collaborative implementation on the Heritage of the Route

The Information Modelling procedure has originated from the collection and direct documentation of data useful to cover the overall knowledge of monumental sites belonging to the Route. In this way, aspects coming from *general/legislative analysis*, *historical analysis*, *architecture*, *accessibility*, *territory*, *technological and conservation analysis* have been considered. The joint research, developed by PROMETHEUS interdisciplinary team, has led to the preliminary definition of an extremely heterogeneous and complex data flowchart, with the objective of developing a unified strategy for the mapping and evaluation of heritage sites. In this process, international and European Guidelines, as those provided by ICOMOS and UNESCO, have been considered and applied for the analysis[9].
The adoption of a digital database for the management of information flows has been evaluated to set an on-site collection of direct data (texts and images) in a more immediate and structured way[10]. The objectives of knowledge and direct documentation of information on the historic buildings have been managed similarly to the growth and structuring of a 'cognitive map' on the monument-site-territory architectural systems[11].
In this system, data have been revised to automatically assume a query grammar, which is the basic workflow both to the achievement of logical results and to the development of a collaborative transfer of knowledge between researchers. As qualitative data are properly inserted in flow grids and weight algorithms, they can be translated into quantitative parameters and generate evaluation criteria as well as identifying classes for intervention and emergency assets (fig. 3).
The layout adopted for the census system has been structured in the format of a card, divided in sections and fields for further information. Its query semantics are divided between:
- *Free Fields*, that are oriented on contents and define 'themes' and 'keywords' that can guide the qualitative coherence of the information. Photographic and drawing data are included in these fields;
- *Option Fields*, that are oriented on values and define parameters and weights that can compose the quantitative evaluation of the information. Value lists are applied in these fields (figs. 4, 5).

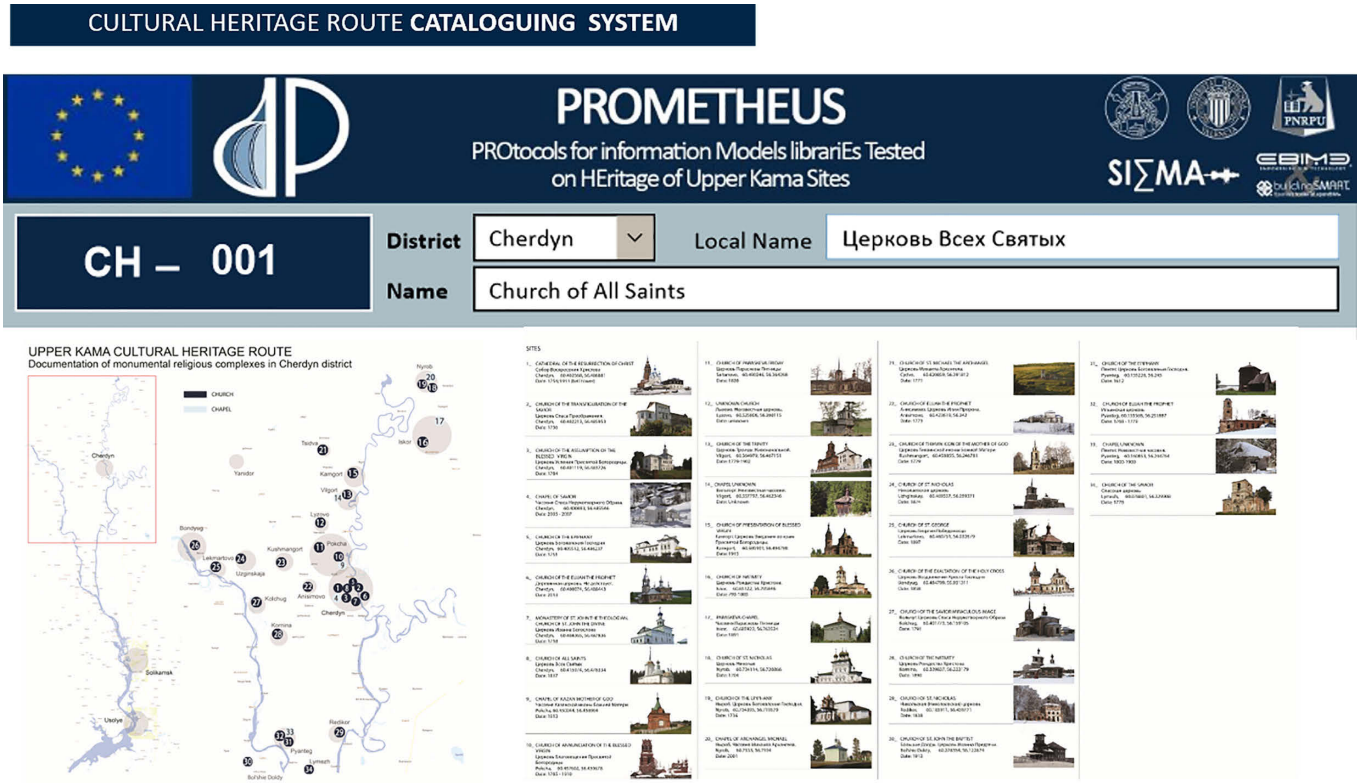
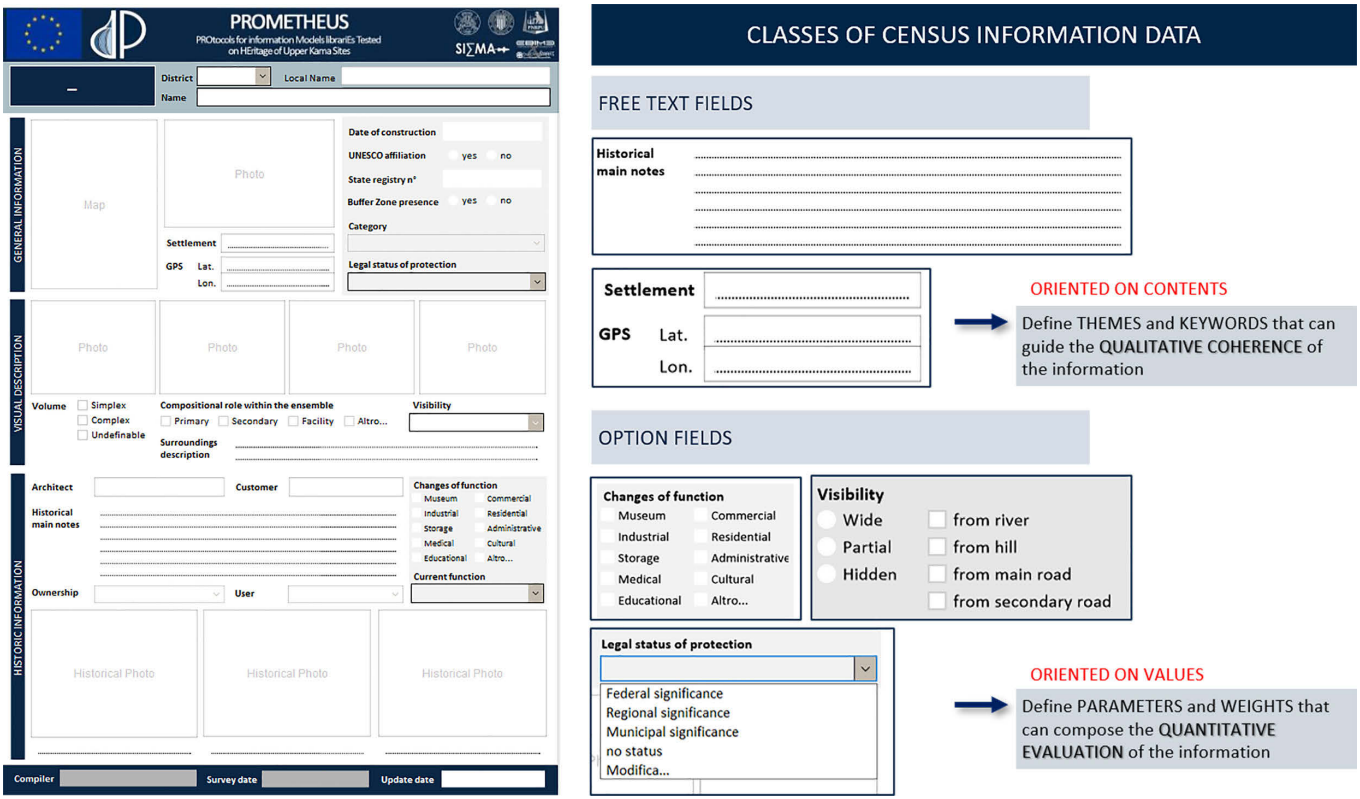


Fig. 3 - The identification code (District_Number) established for each Heritage site of Upper Kama and adopted to relate information from census, survey and modelling activities into the main digital database of documentation.



The use of a main code to identify each site along the Route ('District_Number') has supported the census by multiple researchers, with the integration of different devices on a main central database. In this way, the international team has been allowed to work also in remote connection, integrating the different expertise to complete and review the sections of data and information provided by the census card. In particular, the sections implemented are:
- *General Information*: site overview and main data considering local administrative Cultural Heritage and European Cultural Heritage framework;
- *Historical Analysis*: availability of historical archival data, drawings, photos and references;
- *Architectural Analysis*: composition, geometry and visual aspects of the building;
- *Accessibility*: advancing conservation and sustainability purposes from the quality of the visiting experience, in the scale of the building, the site and the area;
- *Territorial Analysis*: regarding the connection between territory and heritage in the evaluation of territorial resources, landscape qualities and their consumption;
- *Constructive Analysis*: assessing technological characters of primary founding structures, secondary systems and complementary elements of historical techniques;

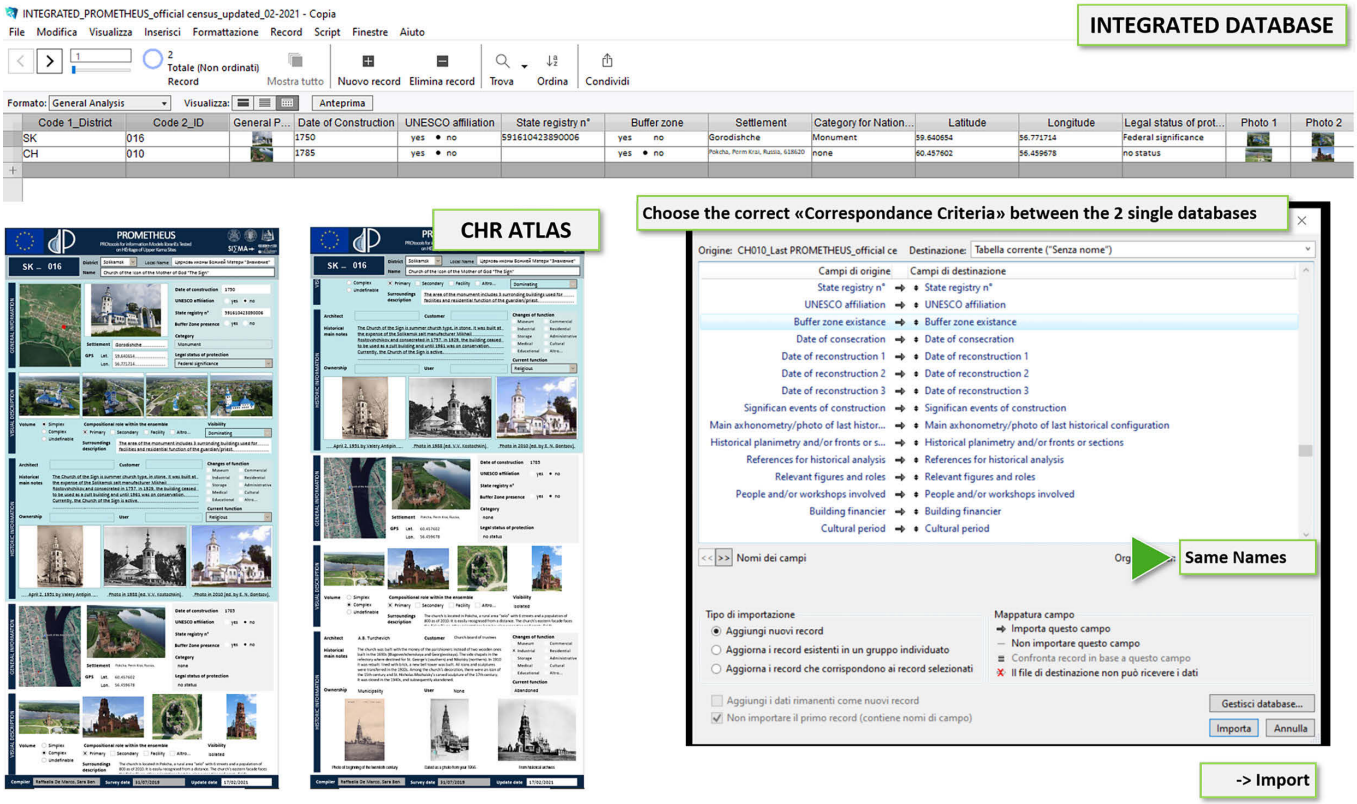
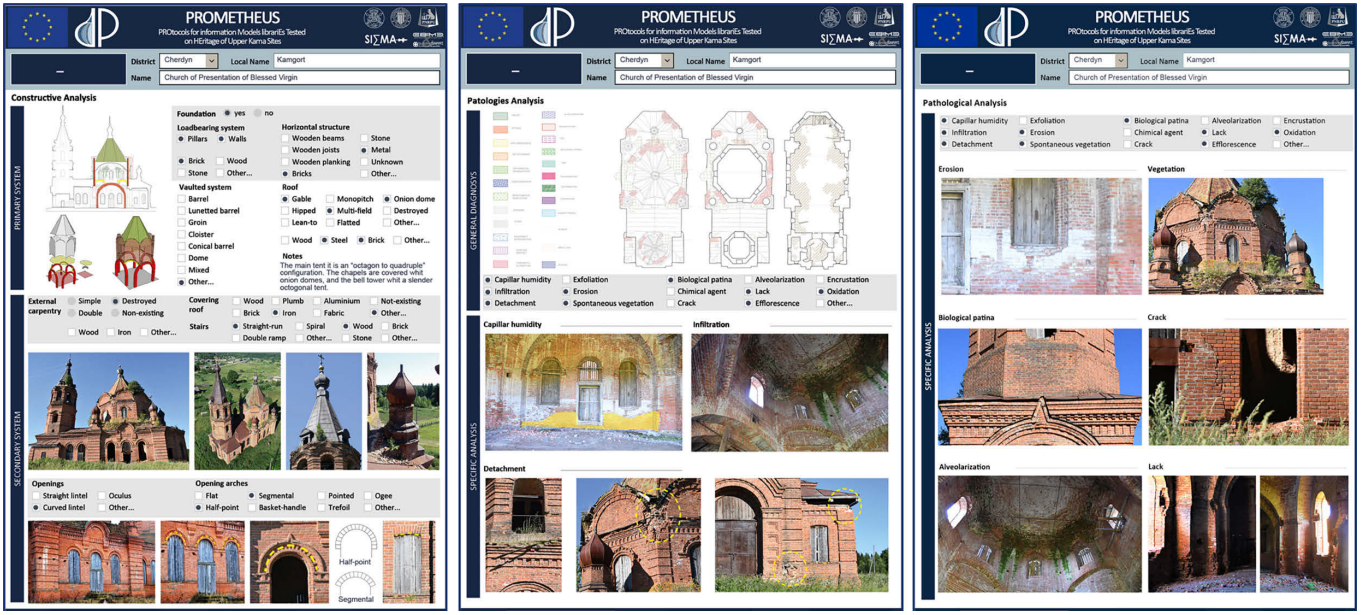


Fig. 4 - The main layout designed by the PROMETHEUS International team to collect and order information from direct and archival census on the monumental sites. Examples of information classes between text fields and option fields composed by value lists.

Fig. 5 - The management of information systems to proceed the integration of data and contents from different researcher's archives to the mainstream PROMETHEUS database, developed within a FileMaker archive.



- *Pathological Analysis*: classification and coding of degrades and decay pathologies (Figs. 6, 7).

In this way, a multiflow database has been developed, and its structure has been assumed to envisage the modelling strategy from information archive, respecting the multi-scale dimension of Upper Kama heritage.

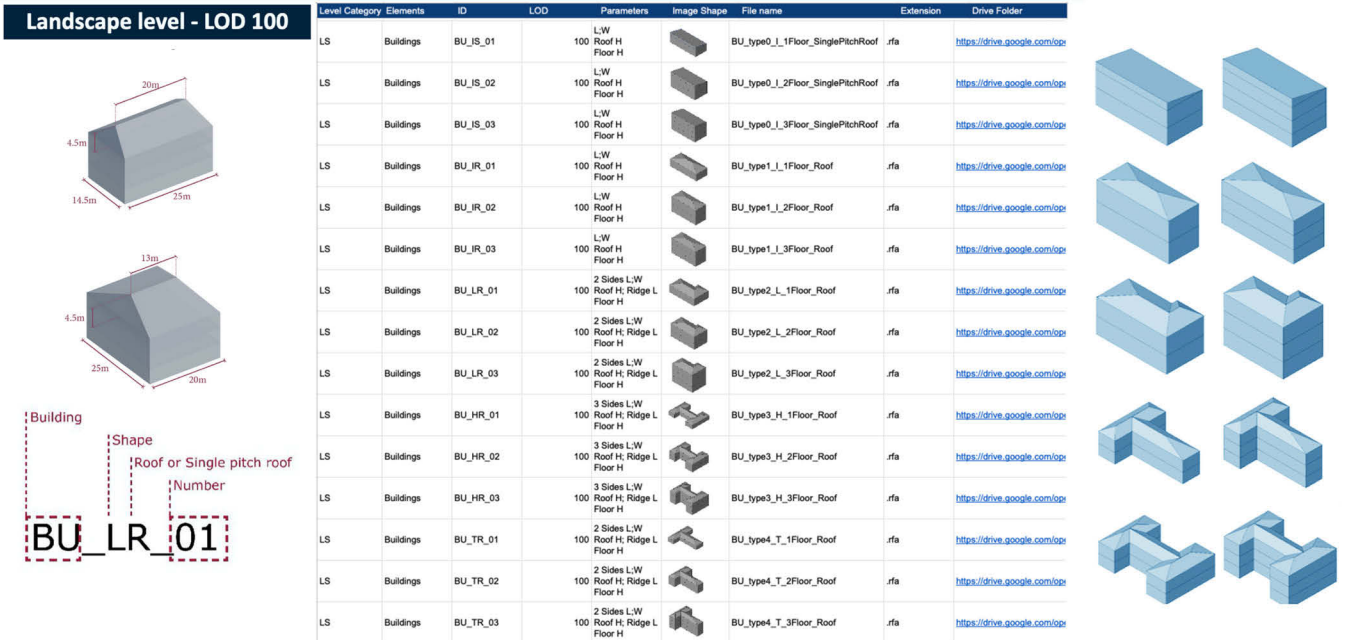
A multi-scale information system for the representation of the Upper Kama heritage

The digital simulation of the complexity of the relationships between artificial and natural elements defines a multidimensional representation system of the landscape. Where the architectural and territorial system intertwines within a dynamic network of combinations and flows, in which not only the model is a mere simulation of the form of architecture but becomes an expression of an effective reading and representation tool for the description of the landscape and the cultural, architectural heritage of the Upper Kama.

The PROMETHEUS project aims to define an informative narrative system by defining a three-dimensional representation model that evokes the formative rules of the landscape and proposes qualitative aspects within a catalog of elements that describe the architectural characteristics, stylistic variety, constructive solutions, and a multiplicity of building materials, with relative pathologies of degradation and conservation, such as to characterize the identity of the Upper Kama region. The operations to carry out this type of information modeling can be summarized in different time of actions: knowledge, identification of variables, structuring of dynamic and interactive interconnection systems for the reading, and use of the data represented.

Fig. 6 - Examples of census cards about the Technological and Constructive analysis and the Pathologies analysis for conservation purposes developed on sites in Upper Kama Route. The card structure has been developed from the research collaboration between the project teams by University of Pavia (Italy), Universitat Politècnica de València (Spain) and SISMA s.r.l. (Italy).

Fig. 7 - Examples of census cards about the Accessibility analysis and Territorial analysis for visit and resilient regeneration of Upper Kama sites. The card structure has been developed from the research collaboration between the project teams by University of Pavia (Italy), Universitat Politècnica de València (Spain) and Perm National Research Polytechnic University (Russia).



Level	Category	Elements	ID	LOD	Parameters	Image Shape	File name	Extension	Drive Folder
LS		Buildings	BU_IS_01	100	L;W Roof H Floor H		BU_type0_I_1Floor_SinglePitchRoof	.rfa	https://drive.google.com/op
LS		Buildings	BU_IS_02	100	L;W Roof H Floor H		BU_type0_I_2Floor_SinglePitchRoof	.rfa	https://drive.google.com/op
LS		Buildings	BU_IS_03	100	L;W Roof H Floor H		BU_type0_I_3Floor_SinglePitchRoof	.rfa	https://drive.google.com/op
LS		Buildings	BU_IR_01	100	L;W Roof H Floor H		BU_type1_I_1Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_IR_02	100	L;W Roof H Floor H		BU_type1_I_2Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_IR_03	100	L;W Roof H Floor H		BU_type1_I_3Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_LR_01	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type2_L_1Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_LR_02	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type2_L_2Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_LR_03	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type2_L_3Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_HR_01	100	3 Sides L;W Roof H; Ridge L Floor H		BU_type3_H_1Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_HR_02	100	3 Sides L;W Roof H; Ridge L Floor H		BU_type3_H_2Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_HR_03	100	3 Sides L;W Roof H; Ridge L Floor H		BU_type3_H_3Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_TR_01	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type4_T_1Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_TR_02	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type4_T_2Floor_Roof	.rfa	https://drive.google.com/op
LS		Buildings	BU_TR_03	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type4_T_3Floor_Roof	.rfa	https://drive.google.com/op

Fig. 8 - The importance of formalizing a standard modeling protocol for an organic result of the model design activities, in which different disciplines are involved, in which the application aspects of the model and the information it must contain are decided. Example of a structured abacus using an identification code for the territorial-scale census of the district of Solikamsk (Upper Kama).

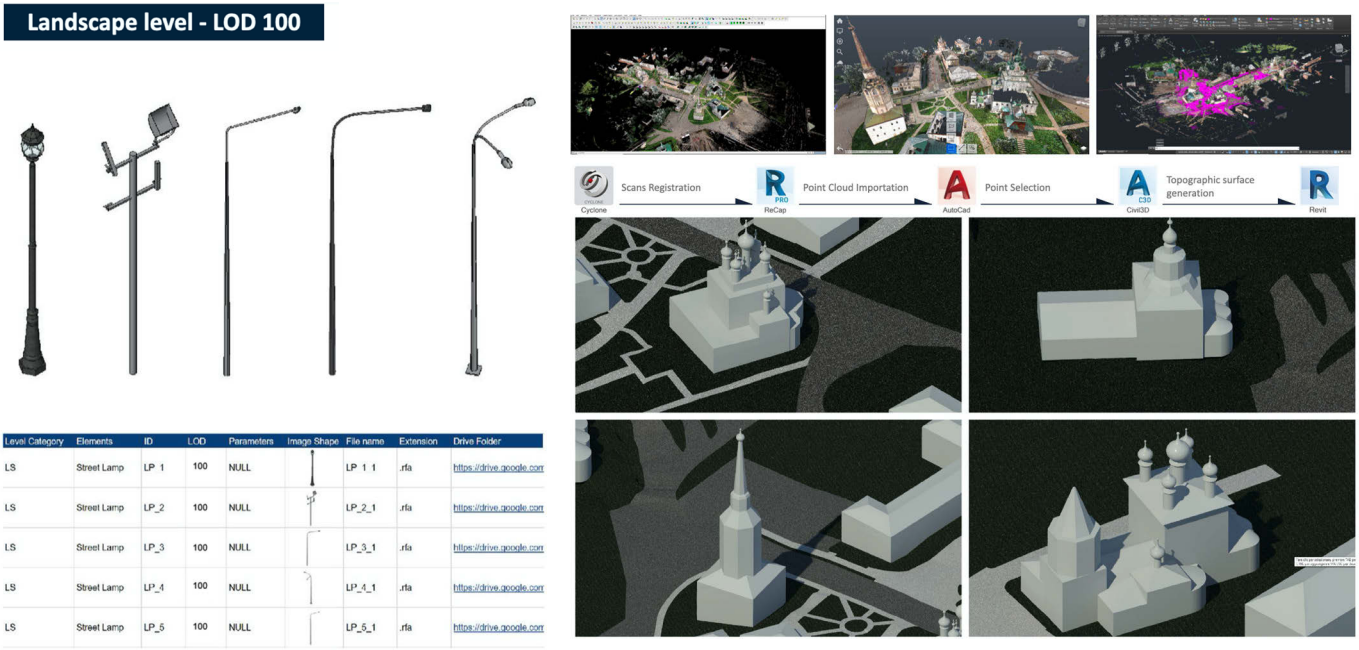
These reflections are the concepts underlying the design of a responsive model, capable of describing quantitative and descriptive aspects of the Upper Kama territory through the definition of sub-models which, qualified in the form of a conceptual symbol, are descriptors of specific qualitative values.

To achieve this, a modeling protocol has been structured, collected within a coordination document (BEP- Building Execution Plan[12]) which outlines the project guidelines by

These reflections are the concepts underlying the design of a responsive model, capable of describing quantitative and descriptive aspects of the Upper Kama territory through the definition of sub-models which, qualified in the form of a conceptual symbol, are descriptors of specific qualitative values.

To achieve this, a modeling protocol has been structured, collected within a coordination document (BEP- Building Execution Plan[12]) which outlines the project guidelines by defining permissions, applications, processes, and workflows.

The document defines the information representation rules and the stylistic choices adopted within the project by defining the unique alphanumeric codes used for the classification and nomenclature of the elements, the categories, and levels of detail of representation of the model, the informative parameters[13].



Level Category	Elements	ID	LOD	Parameters	Image Shape	File name	Extension	Drive Folder
LS	Street Lamp	LP_1	100	NULL		LP_1_1	.rfa	https://drive.google.com
LS	Street Lamp	LP_2	100	NULL		LP_2_1	.rfa	https://drive.google.com
LS	Street Lamp	LP_3	100	NULL		LP_3_1	.rfa	https://drive.google.com
LS	Street Lamp	LP_4	100	NULL		LP_4_1	.rfa	https://drive.google.com
LS	Street Lamp	LP_5	100	NULL		LP_5_1	.rfa	https://drive.google.com

Fig. 9 - For the description of the urban level, the furniture elements were modeled, categorizing them into families of elements. For these types of elements, it was preferred not to parameterize the model, considered unnecessary for the descriptive purposes of the territorial system.

The three-dimensional modeling actions are supported by heterogeneous data collected using survey techniques. The geometric data is derived directly from the point cloud or through automatic recognition processes through specific software or the extrusion and modeling of local components inside the model project without resorting to pre-built object libraries[14].

To the geometric component of the model are added the information components that have the purpose of qualifying the models, giving them an added value result of the analysis investigations and instrumental acquisition of the survey activities and the structured census action through the compilation of information sheets aimed at collect data based on specific indicators at the landscape, urban and architectural-technological level. These indicators collected within the census forms will be translated into compilable model categories for structuring the information properties of the different model categories.

To structure an accessible and interoperable information collection platform, form, using a methodological approach of Building Information Modeling applied to Cultural Heritage opens up a potential range of applications, allowing the flow of data and the possibility of management for integration at higher scales, extending from the architectural to urban territorial analysis.

Differentiation in the graphic language of representation of the model categories is necessary to prepare multiple hierarchies of contents defined by using primary forms to structure a model system that can describe the territorial condition.
To this end, four levels of representation of the model elements have been defined:
- *Landscape level*: aimed at locating the widespread heritage along the cultural Route;
- *Urban level*: descriptive level of the individual urban centers in which the different relationships between the monument and the urban center are represented, representing main buildings in a synthetic form and the urban furnishings of the center;
- *Monumental Area level*: in-depth model of the monumental relevance area, in order to identify the different areas for safeguarding the historical character of the individual territorial centers. In a single representation

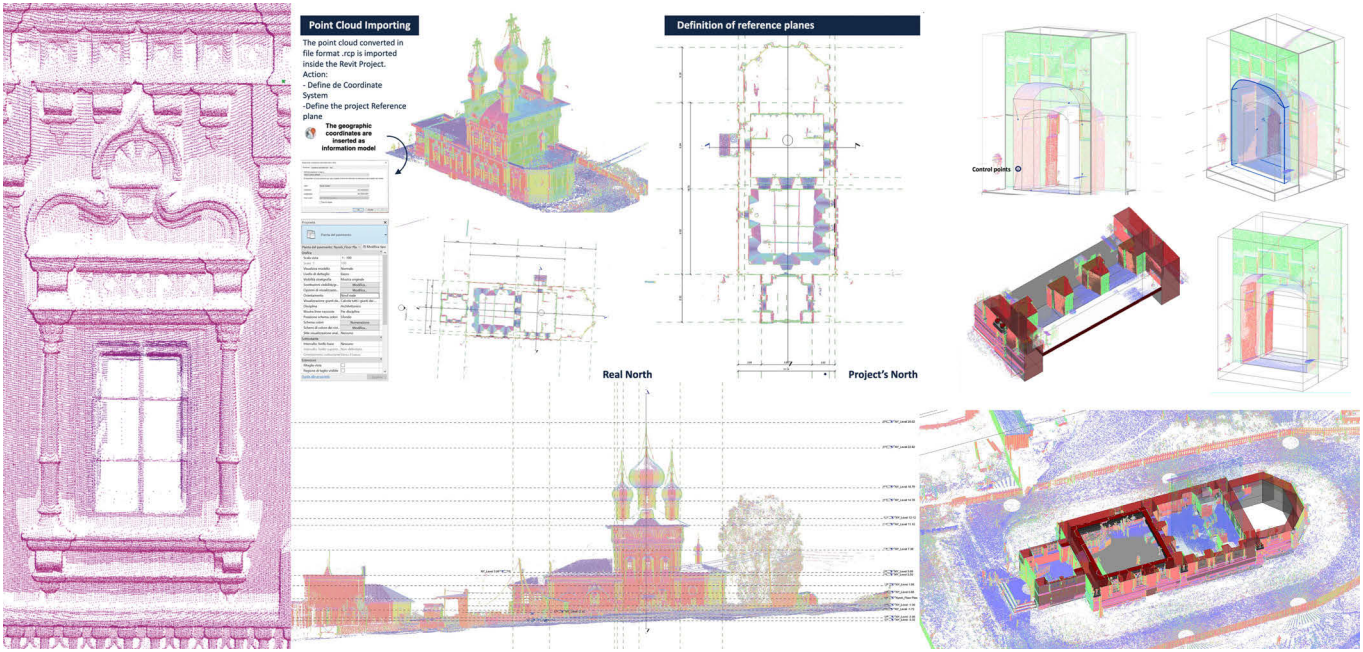
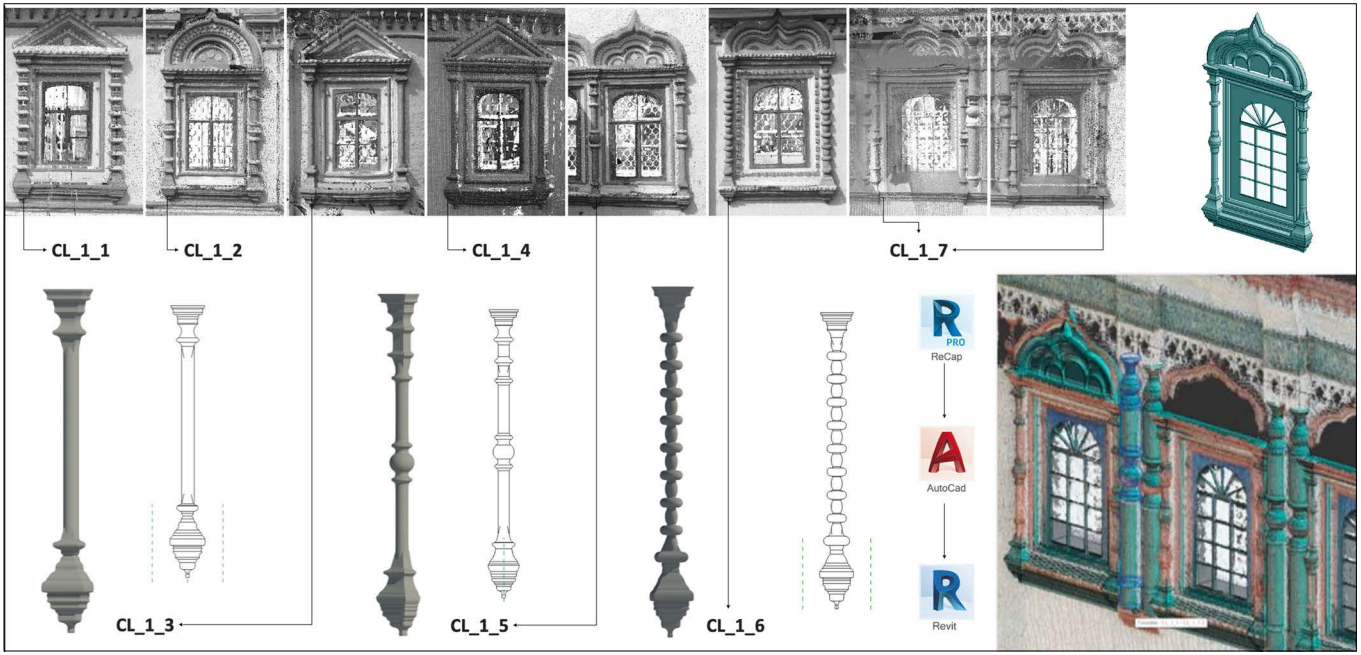
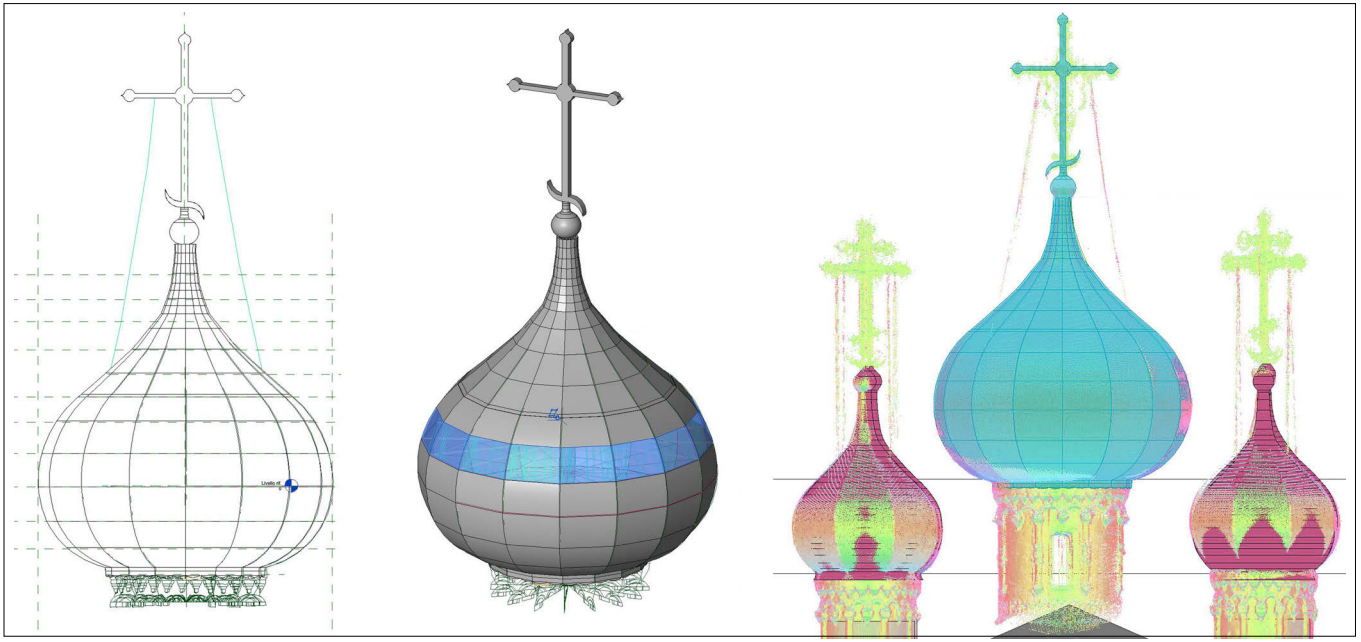


Fig. 10 - The direct comparison between the point cloud data and the model allows structuring modeling strategies adhering to the acquired data.

Fig. 11 - In the analysis of the architectural decoration elements, it was found that if, at first glance, the decoration of the wall surfaces and window frames seems to repeat itself according to precise rules, no window is composed with the same rule as the other. In this sense, the generation of adjustable parameters is complex and, in some cases, redundant.

Fig. 12 - The development of specific families of domes: a first step of drawing the dome's skeleton; a second step involves importing the drawing into the modeling environment, where the individual elements are generated based on the drawn profiles, and a final phase of insertion and validation.


CL_1_1
CL_1_2
CL_1_4
CL_1_7
CL_1_3
CL_1_5
CL_1_6
ReCap
AutoCad
Revit



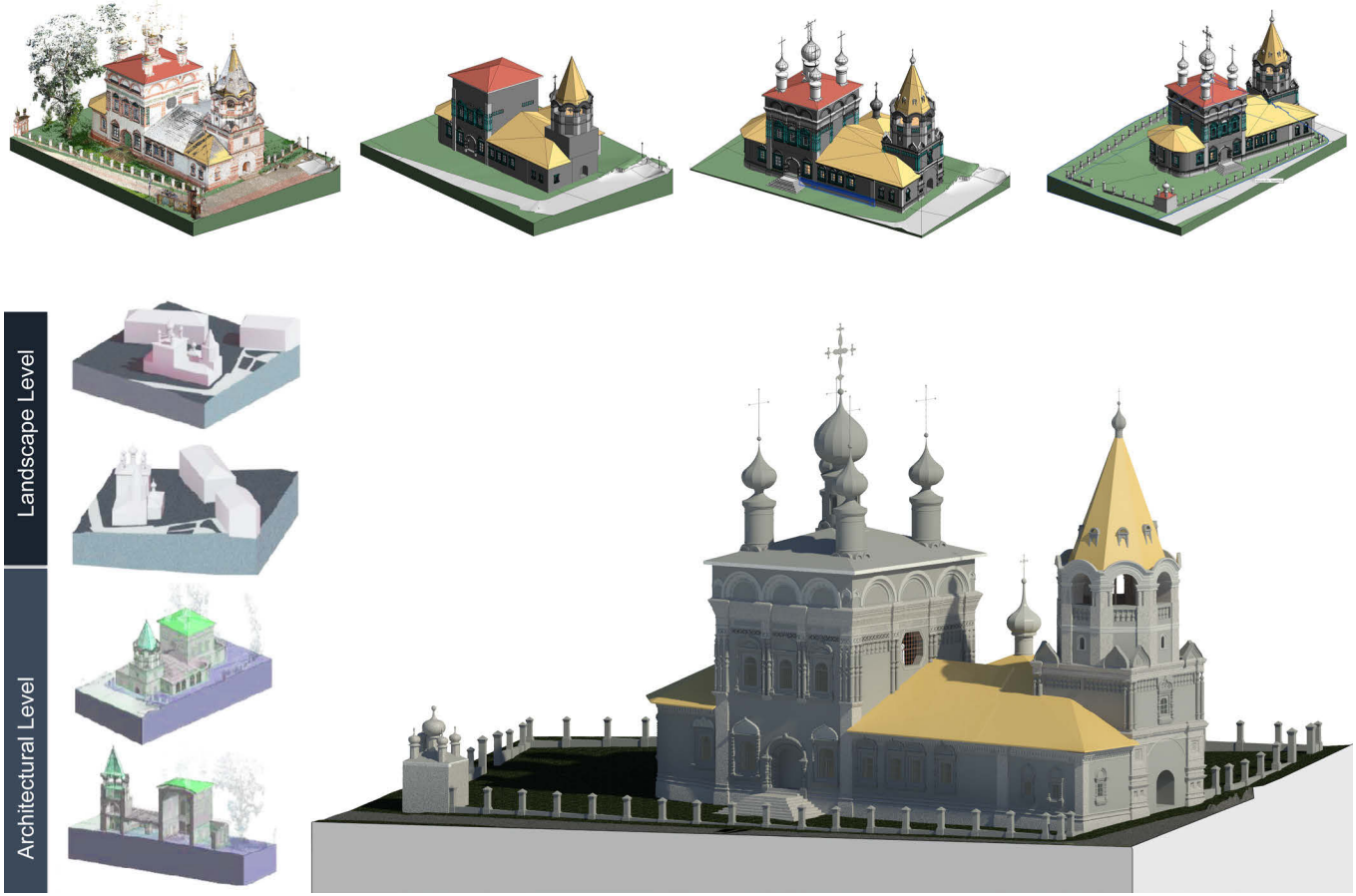


Fig. 13 - The results of the architectural level modeling of the Epiphany church in Solikamsk district. The acknowledgement of 3D modelling for the Epiphany church is due to Hangju Fu (University of Pavia).

model, the landscape features of the area are described in relation to the typological features of the monumental structures present in the area;
- *Monumental Building level*: level of description of the monumental building in which the decorative and technological features of the entire building are represented (figs. 8, 9).
The definition of these model classes have allowed the structuring of a typological abacus of elements divided by categories of typological elements which are then translated into the respective model families, which allows to identify and collect within a shared collection list of all the different categories of elements that are present along the Upper Kama Cultural Route.
Each element identified is matched with the copy of the digital representation inserted within the 3D space. From modeling at a territorial level, in which the model of representation is a symbolic model of the monument represented as an envelope, a white box, the project foresees for some selected case studies the qualification of the models of the monuments going down to a scale of representation at the level of architectural detail, in which it will be possible to read the components and the decoration of the churches. Within the model, the data will be distinguishable through a diversification between model components and information components (fig. 10).

Conclusions

The choice of a multi-scale representation model stems from the awareness of the vast historical-architectural catalog of elements that characterize the architecture of the Upper Kama sites. Therefore, the investigation operations and the writing of a specific manual for collecting the model components resulted in the structuring of the data integration processes through the direct comparison between real objects and virtual models. The conservation and management of the built heritage of buildings is a complex process that requires analysis at different scales, a multilevel through the categorization of the information component to be associated with the model (fig. 11).
In the BIM modeling protocol, the information component supported by the compilation of census forms plays a decisive role in the qualification of the model geometries. The value of information uniquely associated with model components should be considered and researched with the same importance as researching geometric conformity methodologies. The realization of HBIM-type models based on modeling criteria that reflect the qualitative aspects and the formal characterizations of the architectural elements (fig. 12).
The methods of data acquisition, processing, and recognition affect the quality and possibilities of representation through integrated techniques implemented and the LoD defined in the design phase. The different sectoral skills of the researchers involved in the project are the cornerstone of the search for a method that can determine an interoperable and shared protocol to represent the complex monumental system (fig. 13).

Acknowledgments

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 821870.

Notes

1. The editorial responsibility of the contribution is recognized to Raffaella De Marco for paragraphs 1 and 2, to Anna Dell'Amico for paragraphs 3 and 4.

2. "Cultural Heritage is a synchronized relationship involving society (that is, systems of interactions connecting people), norms and values (that is, ideas, for instance, belief systems that attribute relative importance). Symbols, technologies and objects are tangible evidence of underlying norms and values. Thus they establish a symbiotic relationship between the tangible and the intangible. The intangible heritage should be regarded as the larger framework within which tangible heritage takes on shape and significance.": ICOMOS 14th General Assembly and Scientific Symposium, 2003.

3. "The quest for the "message" of cultural properties has become more important. It requires us to identify the ethical values, social customs, beliefs or myths of which intangible heritage is the sign and expression. The significance of architectural or urban constructions and the transformation of natural landscapes through human intervention are more and more connected to questions of identity.": Bouchenaki, 2003.

4. Launched by the Council of Europe in 1987, the Cultural Routes demonstrate how the heritage of different countries and cultures of Europe contributes to a shared and living cultural heritage. The latest updates of the Council of Europe related to the topic concern its evidence at UNWTO/UNESCO 4th World Conference Declaration on Tourism and Culture (Kyoto, 2019) and the premises of a Cultural Routes Database by the European Institute of Cultural Routes (EICR) as an online platform accessible to the public to host a structured and extensive database organizing all network members: <https://www.coe.int/en/web/cultural-routes> (last accessed May 23 2021).

5. Some examples: Spanish pilgrimage Routes, Moorish architecture in Andalusia, the industrial archaeology of the Rhine valley, the network of Charterhouses between France and Italy. The list is still increasing, with the last recent update on 28-29th April 2021, bringing the programme to 45 certified Routes.

6. See ICOMOS 16th General Assembly "Charter on Cultural Routes", 2008.

7. For a more detailed introduction to Upper Kama Cultural Heritage Route and its features of cultural landscape, see De Marco, Dell'Amico, 2020.

8. See Parrinello et al., 2019.

9. Between them: "Tourism Management at UNESCO World Heritage Sites" (2018), 2018; ICOMOS-ISCS "Illustrated glossary on stone deterioration patterns" (2008).

10. See Bocconcino, Manzone, 2019.

11. See Gigliarelli et al. 2020.

12. BIM Execution Plan is a document aimed at describing in detail the requirements for the exchange of detailed information in a BIM protocol.

13. See Dell'Amico, 2020.

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1.

05 OPTIMIZATION PROCESSES OF POLYGONAL MODELS FOR MANAGEMENT IN WEB-BASED INFORMATION SYSTEMS

Valeria Cera

Abstract

This paper is part of the scientific debate concerning the definition of protocols for the structuring of digital models, rendering examples of the architectural heritage, within web-based fruition and query platforms. In particular, the research presents the codification of a methodological proposal together with the description of the various operations, carried out on an exemplary case study.

The described processes deal with the phases of capturing the geometric and colorimetric information of the case study through reality-based survey techniques and analyse the subsequent structuring of digital replication carried out by automatic decimation algorithms, retopologization processes and texture baking.

The aim of the study is to provide a possible protocol, in line with the approaches described in literature and widely validated, to be applied in heritage digitization projects and construction of online platforms for the analysis and optimized management of digital twins.

Il contributo si inserisce nel dibattito scientifico concernente la definizione di protocolli di strutturazione di modelli digitali, restitutivi di esemplificazioni del patrimonio architettonico, all'interno di piattaforme di fruizione e interrogazione *web-based*. In particolare, la ricerca presenta la codifica di una proposta metodologica di cui sono descritte le diverse operazioni, condotte su un caso studio esemplificativo.

I processi descritti affrontano le fasi di acquisizione delle informazioni geometriche e colorimetriche del caso studio tramite tecniche di rilievo *reality-based* ed esaminano le successive attività di strutturazione della replica digitale condotte con algoritmi di decimazione automatica, processi di retopologizzazione e *texture baking*.

L'obiettivo dello studio è fornire un possibile protocollo, in linea con gli approcci illustrati in letteratura e diffusamente validato, da applicare in progetti di digitalizzazione del patrimonio e allestimento di piattaforme *online* per l'analisi e gestione ottimizzata dei gemelli digitali.

Introduction

The technological improvement of sensors for the digitization of architectural artifacts together with the fast evolution of ICT applied to cultural heritage have determined an increasingly widespread trend towards the design and implementation of digital information systems in order to variously interrogate and use the constructed models and the documentary apparatus linked to them [Galasso et al. 2021; Luigini et al. 2019].
However, if on one hand the construction of web-based platforms involves theoretical issues underlying the definition of rigorous and appropriate strategies for the correct structuring of the information base, on the other hand it implies the formulation of adequate IT processes for manipulating the digital model in order not to invalidate its online consultation and use [Banfi and Bolognesi 2021; Perticarini et al. 2020; Sànchez Allegue et al. 2018].
The survey tools for data capture and their modeling techniques return digital representations whose complexity, measured by the number of detail polygons that can be produced, grows significantly faster than the ability of graphics hardware to manipulate them interactively as well as the possibility of information systems to archive and manage them. Pushing geometric acquisition towards indiscriminate levels of detail and accuracy is pointless, if it produces models that are practically unmanageable by programs, platforms and the web due to the significant number of surfaces and vertices that constitute them. The answer to the problem given by the polygon mesh simplification algorithms is not enough to solve the question in case the mesh streamlining procedure can involve a loss of detail and/or a significant modification of the topology in areas where, on the contrary, is required more specification. In this way, the obtained digital replicas could have actually lost the identity character of the real object to which they refer both in terms of geometric coherence and fidelity and aesthetic quality of visual perception.
Therefore, in order to gain searchable digital 3D representations which are at the same time, manageable from the point of view of the IT infrastructure, always keeping the focus on architectural precision, accuracy and reliability, they must be subjected to specific geometry reduction processes such as not to compromise visual fidelity and consistent understanding of information content.
In line with this concept, the paper presents the coding of a structuring protocol of digital models, rendering examples of the architectural heritage, within web-based fruition and query platforms.
The proposed methodology comes from the approach already defined within the PRIN CHROME[1] research project and that has been applied to the project actions of the PON FESR SCOPERTA[2] [Cera 2019; Cera et al. 2018]. The protocol was subsequently improved on the occasion of the study activities relating to the scientific collaboration established between the Urban / Eco Interdepartmental Research Center and the Diocese of Teggiano-Policastro[3] and it is explained below in its various operations, carried out on a case study selected for demonstrative purpose but it is repeatable for other examples of historical construction.
Specifically, the processes described tackle the phases of capturing the geometric and colorimetric information of the case study through reality-based survey techniques and analyze the subsequent structuring of digital replication carried out with automatic decimation algorithms, retopologization processes and texture baking, suitably defined for the querying of the model in an online information system.

Reality-based data acquisition

The process of structuring the digital model is here presented applied to the pulpit of the Church of San Michele Arcangelo in Padula.

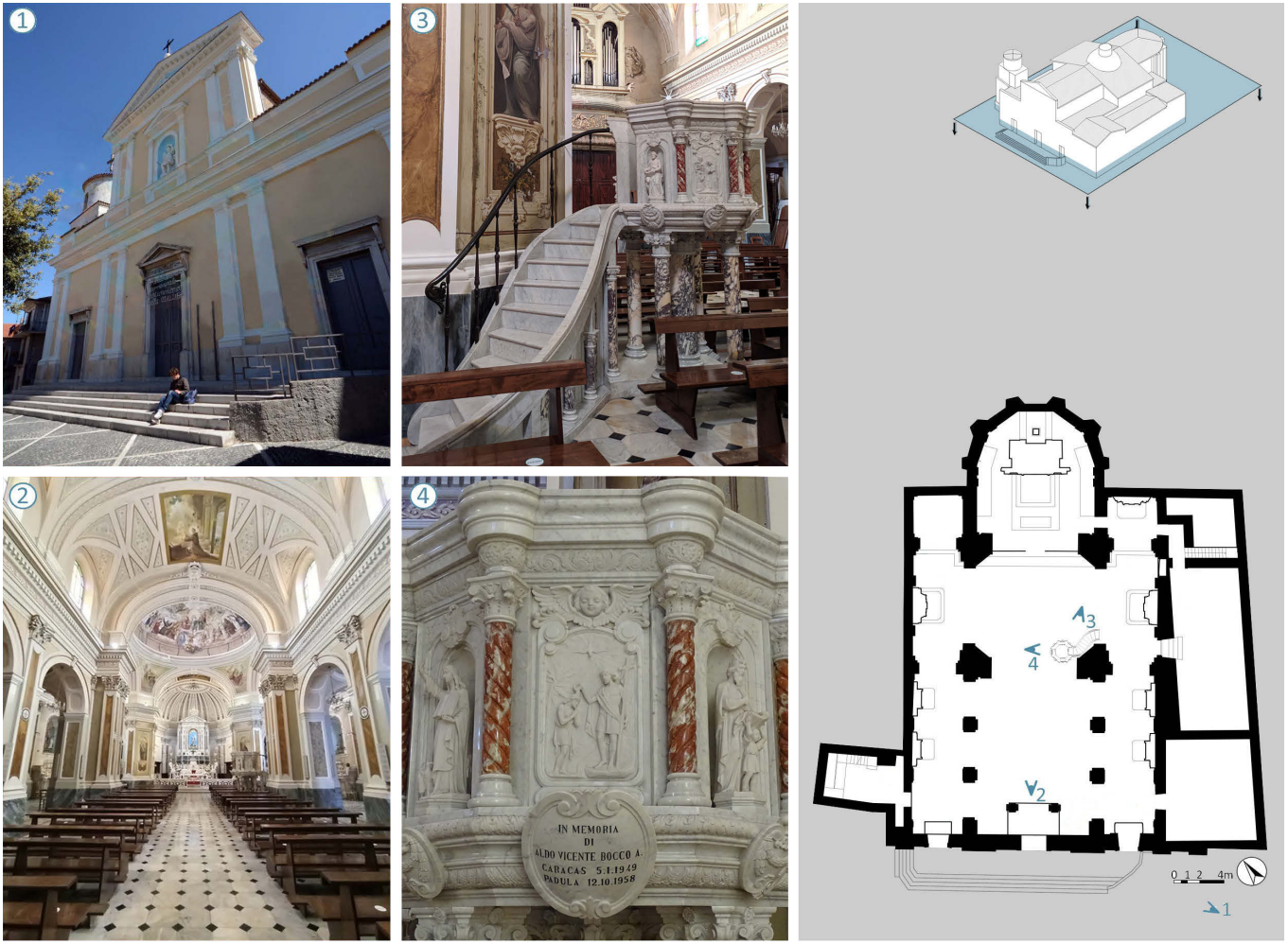


Fig. 1 - Church of San Michele in Padula. Photographic overview.

The first phase of the process focuses on the capture of geometric and colorimetric data, from which it will be possible to build a digital model, representative of the object of study, systematized according to its suitable use in web-based platforms.
The pulpit has significant dimensions: 3.30 m x 2.40 m overall dimensions on the horizontal plane, 2.84 m total height, a depth (of the raised octagonal platform) equal to 1.45 m. It is located near the transept, close to the first separation pillar, towards the altar, between the central nave and the right-side nave of the cathedral of Padula (fig. 1).
Typical expression of the Baroque language, it is entirely made of different colored marbles and it develops on two orders. The first, the lower one, consists of 5 Corinthian columns in black and white marble, designed to support the second level. This level is made by an entablature with sculpted marble shields, and it is surmounted by an octagonal balustrade in white marble composed of bas-reliefs of characters and scenes of Christianity contained in six red and white twisted columns. The two orders are linked by a sinuous 10 steps staircase made of marble.
The pulpit was captured through the acquisition of 7 scans with phase modulation TLS, a tool chosen to meet the contextual need for surveying the entire spatiality of the church as well as for the level of accuracy and geometric precision achievable by using this instrumentation, coherent with the aims of the survey. The scans were carried out at a rather close distance between the captured range maps - of a maximum of 1.5 meters - in relation to the distributive characteristics of the church that hosts it and to its own dimensions. For the same reasons, the stations were distributed along the 3 free sides of the pulpit, since the right side of the pulpit was leaning against one of the side pillars of the central nave and planned with the aim of reproducing the entire shape with fewer holes and possible shade areas, avoiding the tangency of the surfaces. In particular, 2 scans were positioned to frame the lateral ends placed at eye level, 2 scans in correspondence with the empty compartments between the spiral columns supporting the mezzanine, placed at a lower level (approximately 0.90 m), 2 scans in a central position to frame the main elevation of the pulpit, placed at an elevated height (2.05 m) and 1 last station in a central position, at eye level but at a greater distance from the object of about 3.5 m (fig. 2).
Being a plastic element, rich in sculpted elements, an average resolution of 6 mm was chosen at a distance of 10 m and an accuracy of 4x, thus obtaining a thickening step of the range maps of approximately 1 mm at 1.5 m. To limit contacts with the object of study and the environment in which it is housed, no targets, either spherical or flat, were positioned, leaving the identification of natural homologous points to the alignment process, to be traced directly on the architecture. For this purpose, the shots were planned in order to ensure the framing and registration of as many specific geometric elements as possible in order to simplify the subsequent alignment phase of the scans. Choosing not to use targets also responded to the desire of obtaining a 'clean' representation, without extraneous elements that could possibly occlude some specific portions of the texture surface.

Data processing: from point cloud to textured mesh

The alignment of the individual scans was performed with the instrument's proprietary processing and recording software to ensure the most correct rigid roto-translation procedure between the point clouds with deviation values as low as possible.
Lacking targets in the scene, the software allowed the recognition of homologous points to be aligned, through best-fitting procedures of geometric primitives such as planes, edges, and faces.

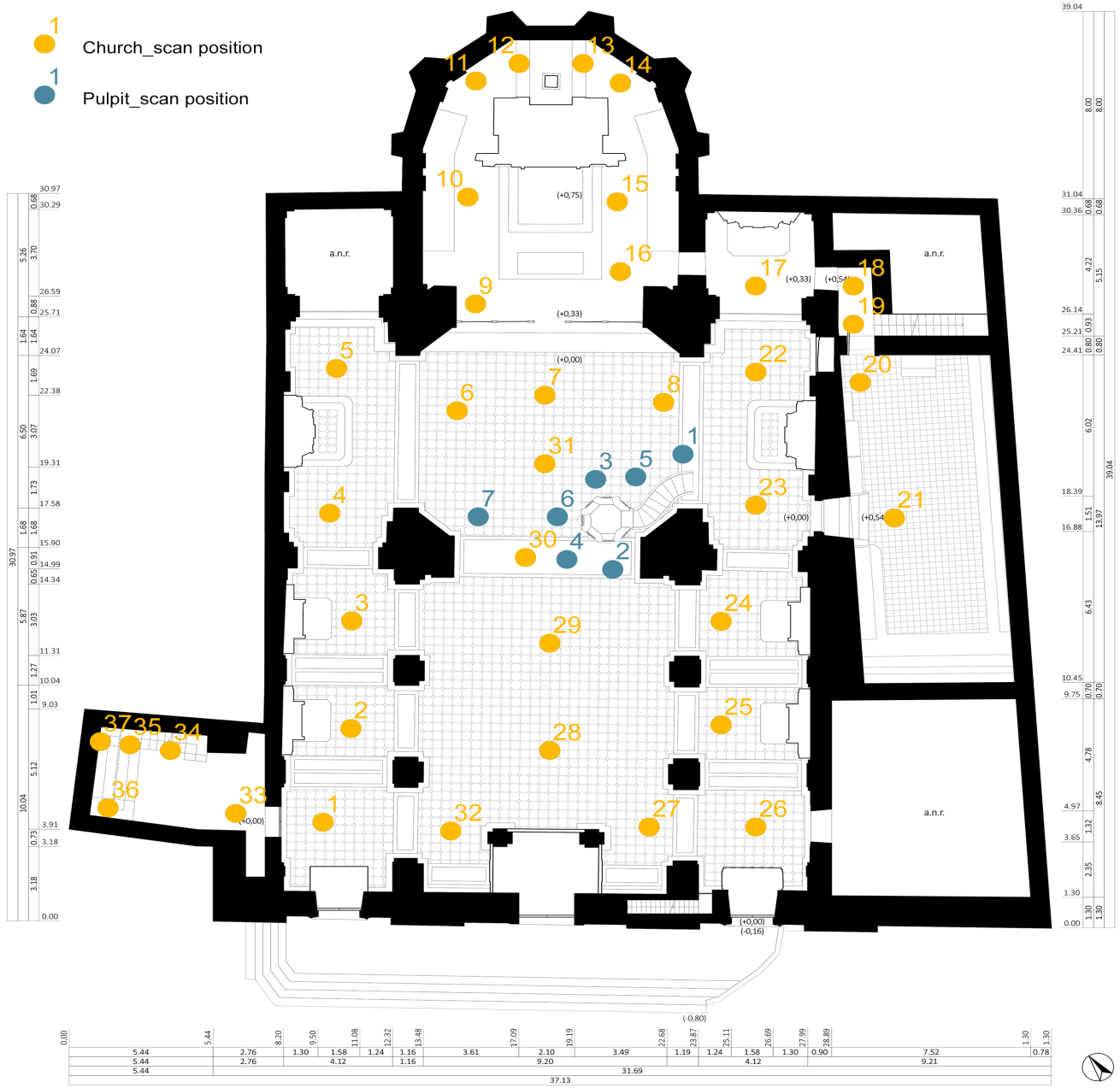


Fig. 2 - Reality-based data acquisition. Schematic drawing of scans positions.

Having recognized at least 3 primitive elements present in the overlapping area between the scans, the 3D positions of the elements to be aligned were identified by the software, used to assign the initial rotation and translation to the scans with respect to the chosen reference system. The elements placed at more than 25 m, were excluded from the alignment procedure, unable to provide accurate position information. However, having acquired large portions of the church that houses the pulpit as well, these areas have provided a wealth of useful elements for the reciprocal roto-translation of the scans.
The automatic procedure did not require any manual integration of further homologous points where no alignment errors occurred. The tension recorded between the different primitive elements present on the individual scans appears to be of the order of a millimeter.
The resulting recorded cloud was transformed, in a second step, into a single polygonal surface through the *RealityCapture* software. The scans recorded were, therefore, imported in compatible .ptx format, maintaining their spatial location.
Subjected the scans to a verification of the alignment process for the automatic computation of their position and orientation in the scene, the polygonal model was derived from the calculation of depth maps. Starting from the extraction of tie points from the different scan clouds, exported with reflectance information, the triangular mesh was calculated by imposing exactly the points captured with the laser scanner as the vertices of the polygons. The density of the cloud was filtered by requiring that points with an intensity lower than 0.03 to be discarded since they were considered inaccurate. Starting from the lightened data, the polygonal surface was generated in which no topological inconsistencies were highlighted. The result is a representation that, from the geo-metric point of view, is quite precise and accurate, consisting of 57,476,728 polygons and 28,759,871 vertices.
To provide the polygonal model with a considerable degree of visual realism, the texturing operation was carried out using the 'multi-band' calculation method and special frames captured with a Canon EOS1300D SLR.

Mesh simplification and management process: decimation, retopology and texture baking

Once the texturized digital model has been obtained, the formalized protocol works on the cleaning, decimation and re-texturing of the data obtained, according to their adequate use in an interrogation and fruition platform.
The simplification procedure was performed in the opensource application *Meshlab* where the reduction of the number of polygons of the model was preceded by a series of cleaning operations of the digital representation in order to optimize the decimation.
Exported from *RealityCapture* in .ply format, the pulpit mesh was subjected to the following processes in *Meshlab*:
(i) Remove Duplicate Faces;
(ii) Remove Duplicate Vertices;
(iii) Remove Unreferenced Vertices.
The operations identified and therefore eliminated fifty duplicate faces. The subsequent simplification was carried out by pursuing the geometric optimization of the model through a vertex merging algorithm, the Quadric Edge Collapse Decimation. This was preferred because it represents a good compromise between strength, speed and final rendering.
The number of faces to be obtained with the simplification was previously decided, and set l to $2M^4$. For this reason, the model reduction percentage was set to 0. To approximate, for the original form, in the simplified model, a quality threshold of 1 was set, in a range [0,1] in order to compute only well-shaped triangles and the faces with one maximum penalty with a proportional penalty of the shape, lower than the established value. At the same time, the control of the iterative procedure involved

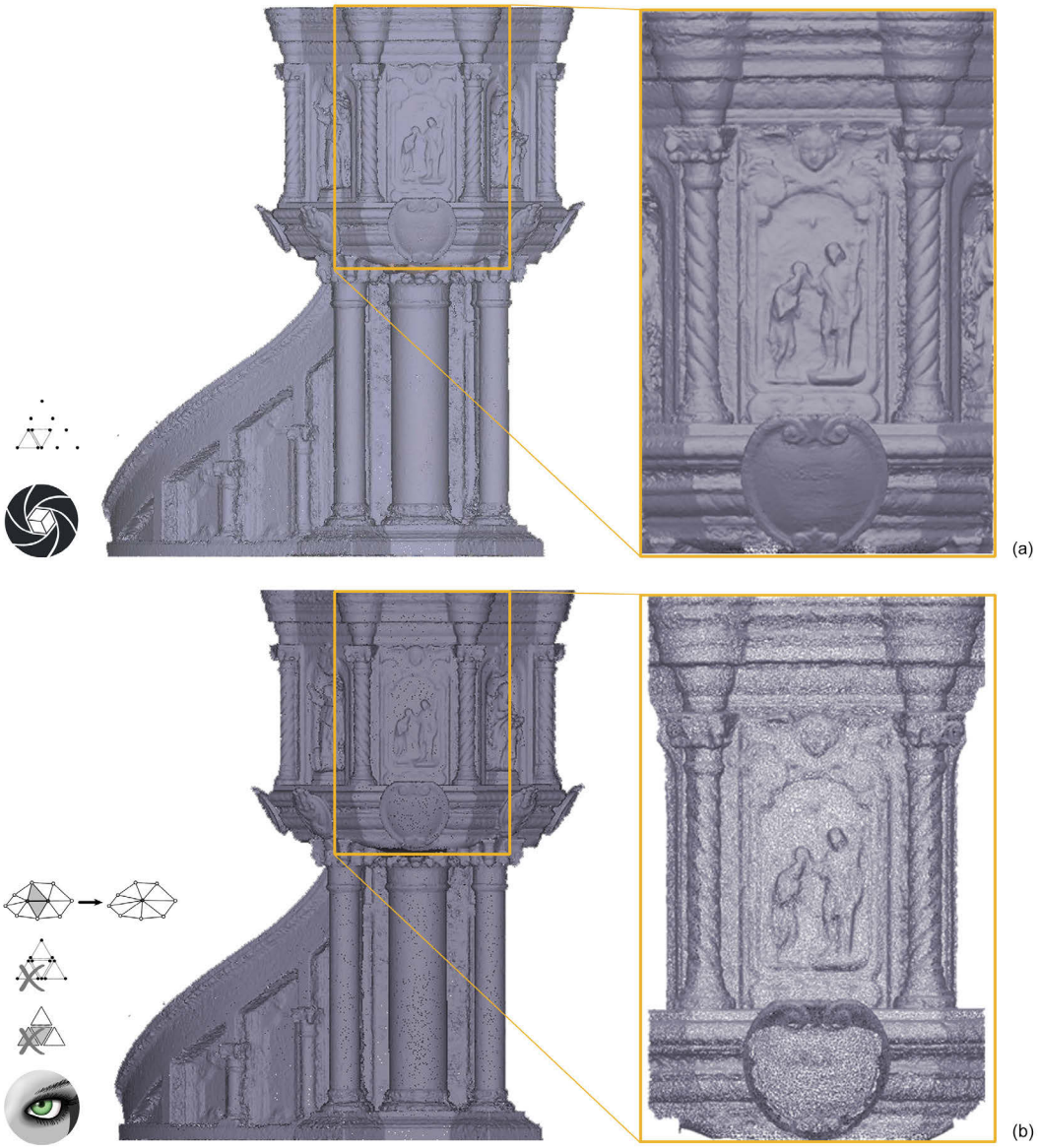
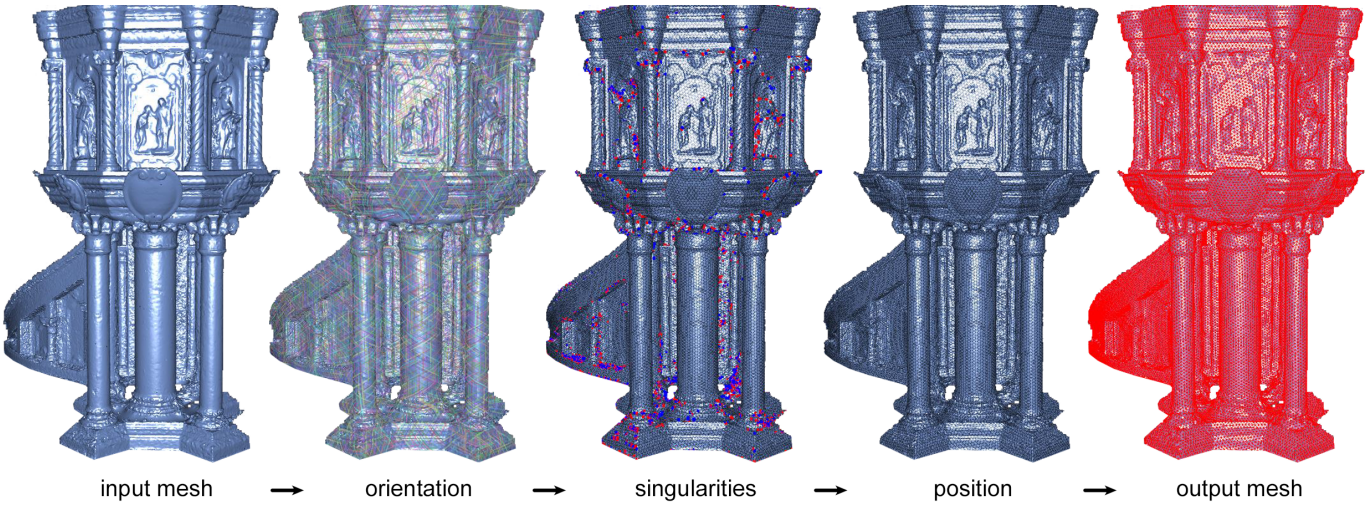


Fig. 3 - Polygonal model decimation process.

compliance with the edges, the normals, the topology, and the optimization of the position of the simplified vertices.
Starting from the high poly mesh, of 28,759,871 vertices and 57,476,678 triangles (fig. 3a), a simplified – low poly mesh – with 1,006,109 vertices and 2,000,000 polygons (fig. 3b) was obtained, imposing a weight for the importance of the edges during the process equal to 1, in an interval [1.0], corresponding to the maximum relevance. An additional clean-up of the reduced model was performed to ensure the removal of unreferenced vertices and triangles with a penalizing shape.
To facilitate the subsequent mesh management in online information systems, a re-topology of the 3D representation was carried out. In the Instant Meshes opensource application, the model was further decimated bringing the number of triangles to 71.67k and their position and orientation was perfected (figs. 4, 5).
In order to not compromise the rendering of the model and maintain geometric fidelity even in the visualization task, following the reduction operation carried out, the detail was recovered through a texture baking process.
With the Blender software, the normal map resulting from the comparison between the high poly mesh and the low poly mesh was calculated. Following the same approach, the color information and ambient occlusion data were processed using the high polygonal content mesh. In this way, even if some geometric data were lost during decimation, the simulated light behavior, in the display and rendering engines, accounts for the effect of the removed details. These maps are in fact projected on the simplified areas of the mesh, reproducing the polygonal complexity of the same regardless of their level of surface specification (fig. 6a). The technique therefore allows, starting from a very complex model, to be projected on one another, used as a base but with a lower number of polygons. The process thus makes the fruition fluid and quick, by virtue of the geometric simplification carried out, while preserving at the same time the realism and coherence of the perception both of the digital



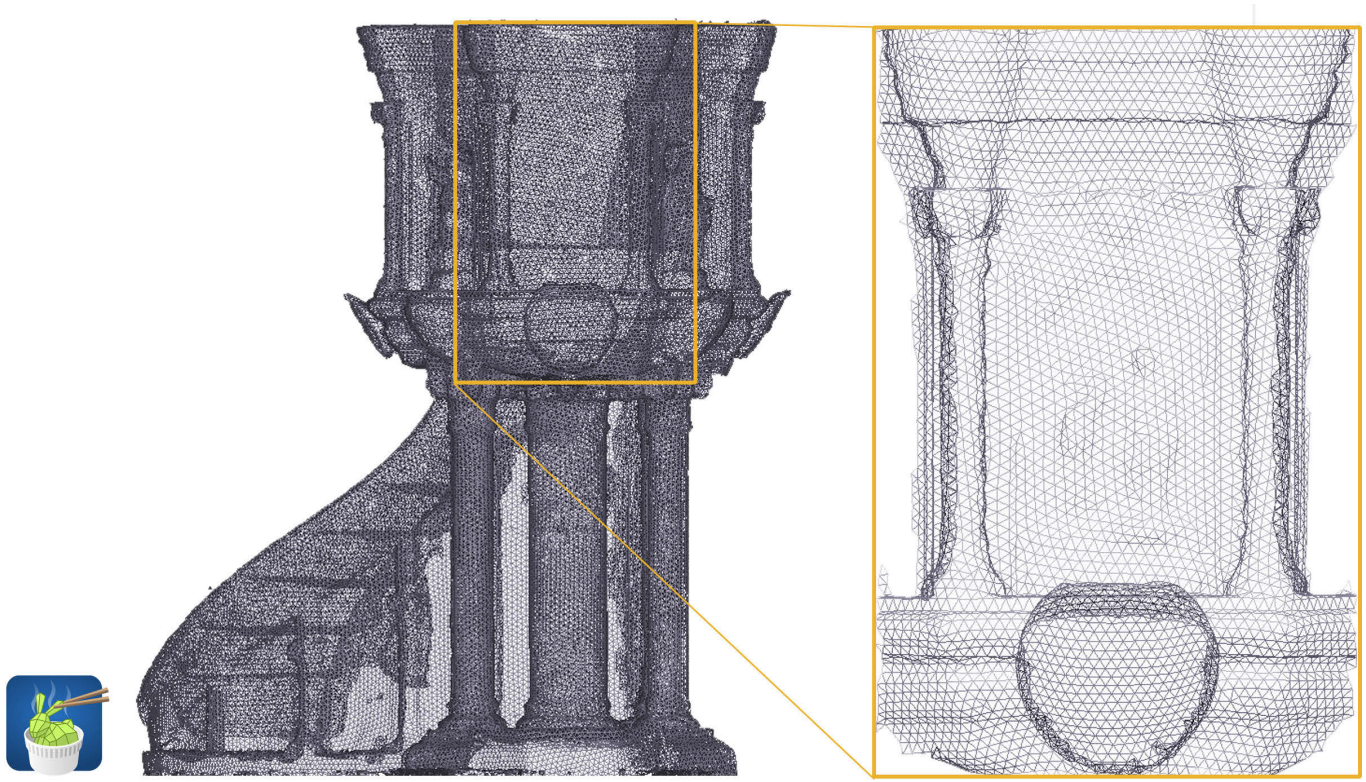


Fig. 4 - Retopology and optimization process.

Fig. 5 - Final decimated and retopologized mesh.

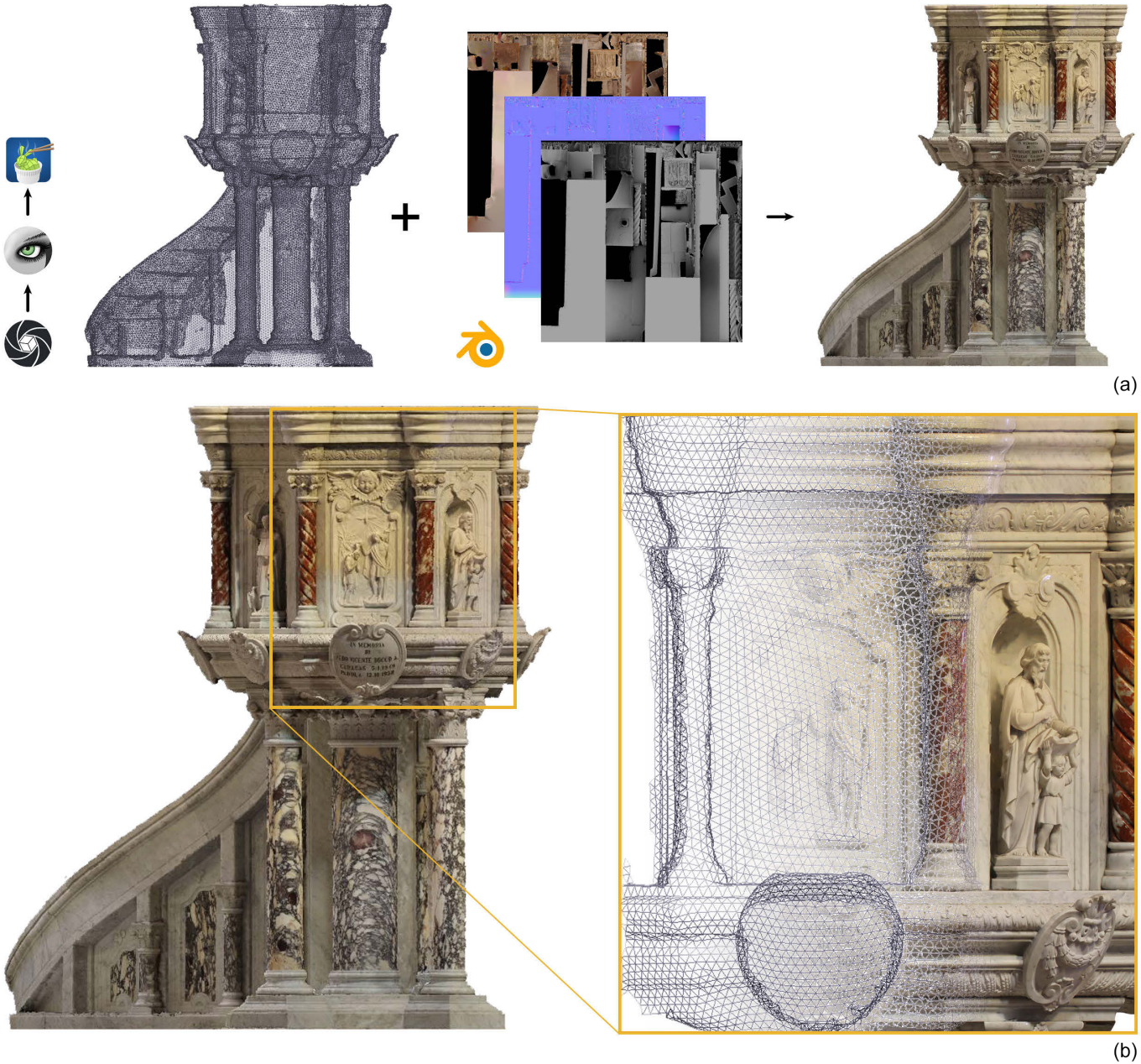


Fig. 6 - Texture baking process. Final result.

representation itself and of the informative contents (think, for example, of the aesthetic quality of surfaces in terms of texture, color and degradation) associated with it (fig. 6b).

Conclusion

The widespread digital literacy of the community and the increasingly massive diffusion of ICT technologies in the field of digital representation of architectural artifacts offer researchers and professionals a very wide range of possibilities in which the compromise between the issues of computer management of 3D models and scientific aspects of the organization of information resources represent a critical node of the question.

In this context, the paper aims to provide a possible operational response by explaining a procedure for structuring digital models gained from reality-based acquisitions of examples of the architectural heritage to be applied in projects for the creation of web-based management information systems. Aware of the vastness of simplification algorithms and applications designed to recover topological inconsistencies of polygonal meshes, the research aims to highlight a possible approach to the management of 3D representations within digital platforms in which the focus is on preserving, above all, the informative coherence of the model, both from a purely geometric to a formal, and perceptive point of view, considering these elements as the fundamental and essential attributes for the identity rendering of a digital architecture.

Notes

1. The CHROME project - Cultural Heritage Resources Orienting Multimodal Experience # B52F15000450001 - is an Italian national PRIN, funded by the MIUR Ministry of Education, University and Research.

2. S.C.O.P.E.R.T.A. Siti Culturali e Offerta di Percorsi Emozionali con Reti di Tecnologie Avanzate B53D18000130007 is a project funded by the Campania Region under the PON FESR 2014-2020 with the aim of implementing technology transfer procedures between research centers and local companies.

3. Scientific collaboration agreement for carrying out study, research, survey activities, aimed at a timely knowledge of archaeological and architectural heritage, necessary for any restoration, located in the area of competence of the Diocese of Teggiano-Policastro.

4. Tests were also carried out with threshold values of 5M and 3M with unsatisfactory final results in terms of IT management.

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06 DIGITAL SURVEYS FOR THE IMPLEMENTATION OF HERITAGE BIM

Michele Calvano, Filippo Calcerano, Letizia Martinelli, Elena Gigliarelli

Abstract

In a Building Information Model, "the Level of Information Needs should be determined by the minimum amount of information required: anything above this minimum is considered WASTE"[1].
This is stated by EN ISO 19650-1, which also defines the concept of 'federation of models', able to express the information complexity that characterises built heritage. In the current research, digital survey procedures are applied for Heritage BIM, whose information system is implemented through Visual Programming Language (VPL) procedures; the survey phase takes into account the quality, quantity and granularity of information needs, avoiding excessive 'waste'.

In un modello informato «I livelli di fabbisogno informativo dovrebbero essere determinati dalla quantità minima di informazioni necessarie [...]. Tutto ciò che va oltre questo minimo è SPRECO»[1]. Questo è quanto enunciato nella EN ISO 19650-1, in cui tra i diversi argomenti si parla anche di "federazione di modelli" con cui è possibile esprimere la complessità informativa che caratterizza il patrimonio storico costruito. Nel lavoro esposto le procedure di rilievo digitale restituiscono modelli che completano il sistema di contenitori informativi attraverso procedure VPL; la fase di rilievo prende in considerazione la qualità, la quantità e la granularità del fabbisogno informativo evitando di eccedere nello "spreco".

1. Model Information Needs

The ever-increasing need for documentation of cultural heritage has led, in the last two decades, to a digital revolution in the field of data capturing and knowledge representation; a condition achieved through the simplification of processes, the miniaturisation of sensors, the change in the use of acquisition devices [Bianchini, Senatore, Catena 2019]. The limits to this advancement have been the storage and sharing of huge amounts of digital data; while the pandemic period has further accelerated the development of infrastructures for fast communication and content sharing, one of the last remaining barriers is the mistrust in new technologies and tools by users [Katz 2020].
Architectural modelling has benefited from digitisation processes, especially in the survey field, thanks to increasingly advanced space capture systems: for instance, LIDAR systems for creating point clouds using laser stations, Structure from Motion (SfM) to generate numerical data from a multi-image process and the Simultaneous Localisation and Mapping (SLAM) technologies used in mobile mapping. All of these technologies can quickly produce an immense amount of data, often redundant for the purpose and use of Building Information Models (BIM). EN ISO 19650:2019 points out that BIM is based on a clear definition of the actual information needs of models, and therefore it has made explicit the concept of Level of Information Need, which, on the one hand, emphasises the importance of information content and, on the other hand, demands information to be limited to what is essential, outlining a conceptual framework for data management by controlling the quantity, quality and granularity of information. Granularity refers to the deconstruction of information to the minimum terms (high granularity) to obtain more effective digital processes when querying BIM models [Succar 2010]. These considerations also involve BIM processes applied to Heritage BIM (HBIM) [Pocobelli et al. 2018; Radanovic, Khoshelham, Fraser 2020], which belongs to a more complex information context, involving several actors of various cognitive domains ranging from history, restoration, technology, diagnostics, etc., whose work produces information to be included and shared by the model (fig. 1).

2. Methodology

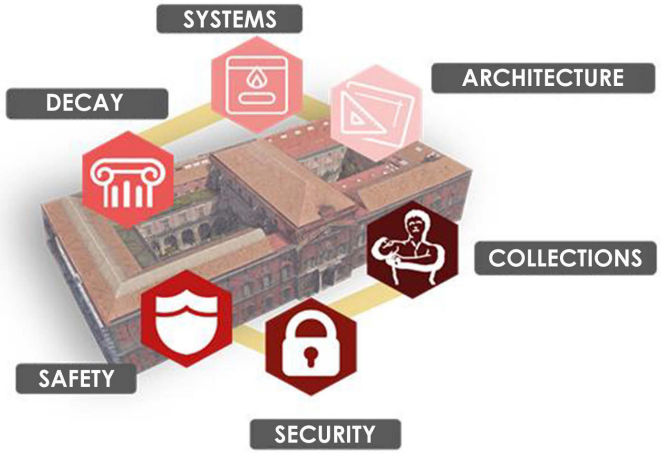
The most common BIM tools are object-based modellers [Eastman et al. 2018], able to represent standard building categories of modern architecture (walls, floors, roofs, etc.), but also to implement, via parametric modelling, typical elements of historical buildings (portals, columns, vaults, mouldings, etc.) for HBIM. The advancement of Scan-to-BIM approach [Biagini et al. 2016; Bolognesi, Garagnani 2018; Lo Turco, Mattone, Rinaudo 2017; Santagati et al. 2021] facilitated by the evolution of software, strengthening the connection between the editing environments of both acquired data (point cloud) and BIM, consolidating the following workflow: semantisation of survey data, critical 'construction' of HBIM objects and information enrichment of the HBIM model, as a result of the integration of HBIM objects.

2.1 Segmentation processes for the semantisation of captured data

The point cloud supports the definition of parametric model objects which, in addition to express the aesthetic instance of the building, assume the role of information containers covering the cognitive domains related to heritage [Quattrini, Pierdicca, Morbidoni 2017].
The geometric survey provides meaning to the signs and components that structure the building's representation. In the past, experts proceeded implicitly, recognising archi-

tectural elements according to a shared graphic nomenclature; today, BIM forces researchers to deal with 'disambiguation' operations, whereby elements are univocally recognised in a hierarchical system that conveys their formal value as well as their constructive behaviour. Upstream of the process is the breakdown structure of the point cloud, with a double objective:
- converge towards the technical simulation of the building via the BIM model;
- create the support for information directly related to model uses.
This breakdown structure, besides enhancing the building's knowledge (e.g. through annotations), simplifies Scan-to-BIM processes by reducing file size. The subsequent parametric modelling of the identified architectural elements is generally manual and still demands distinct care: the point cloud contains much more information than those required by the inputs of parametric objects, not fully responding to the principles of Level of Information Need.
To overcome these issues, we borrow from Reverse Modeling (RM) procedures – where managing the transition from point cloud to continuous NURBS surfaces is usual [Calvano 2016] – the recognition process of the 'structuring geometries', which guides the reconstruction of the surveyed building with continuous surfaces (fig. 2).
The transposition of RM procedure into Scan-to-BIM allows to identify the minimum entities in the cloud – points, lines, open and closed polylines – that define the 'geometric layout', i.e. the entities useful for placing the parametric model objects in the BIM environment [Guadagnoli 2020].

2.2 Geometric paths for placing HBIM objects
The formalisation of line tracing as an element capable of describing the algorithmic process of architectural composition was proposed in the 1980s, with the widespread



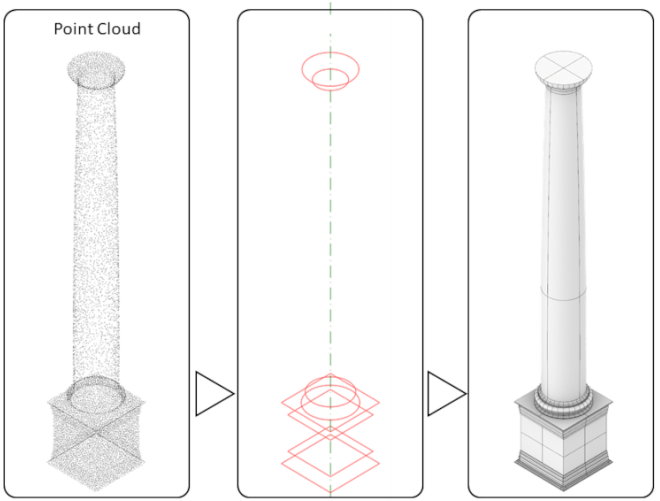


Fig. 1 - HBIM involves several actors of various cognitive domains ranging from history, restoration, technology, diagnostics, etc., whose work produces information to be included and shared within the model.

Fig. 2 - Geometric path detection from a point cloud using the Reverse Modeling process [Guadagnoli 2020].

use of CAD software. George Stiny and William Mitchell theorised the concept of 'shape grammar': a graphic and textual language (sign and metadata) used to describe the characteristics of architecture, giving meaning to a structured collection of elementary signs [Stiny, Mitchell 1978; Mitchell 1990] (fig. 3). This was an ante litteram metadata of simplified signs, in which the graphic entities were not yet associated with a data string, but everything was made explicit in a 2D graphic field.

One of their case studies was the Villa Malcontenta [Palladio 1570], where the two authors illustrated the power of shape grammar for the algorithmic deconstruction of the villa's compositional processes: a sort of visual language that progressively expressed the sequence of actions that determine the shape genesis of the building. The '2D' operations of Stiny and Mitchell are now reproducible and implementable using Visual Programming Language (VPL) procedures [Spallone, Calvano 2019]. The VPL language coupled with BIM enables architectural models consisting of parametric informed objects. The resulting workflow when associating the two tools is as follows:

- definition of the geometric framework of the model (geometric path);
- modelling and information enrichment of HBIM objects;
- association of the HBIM objects with the geometric path.

The standard workflow to link CAD and BIM environments (fig. 4) starts from the recognition of BIM components

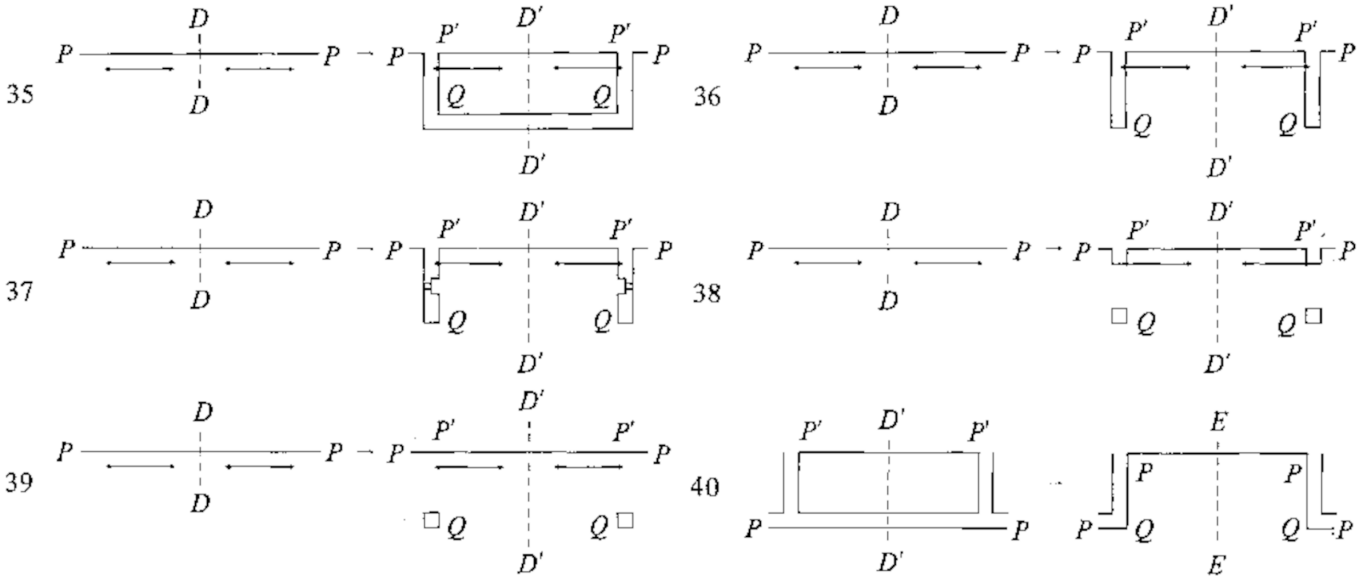
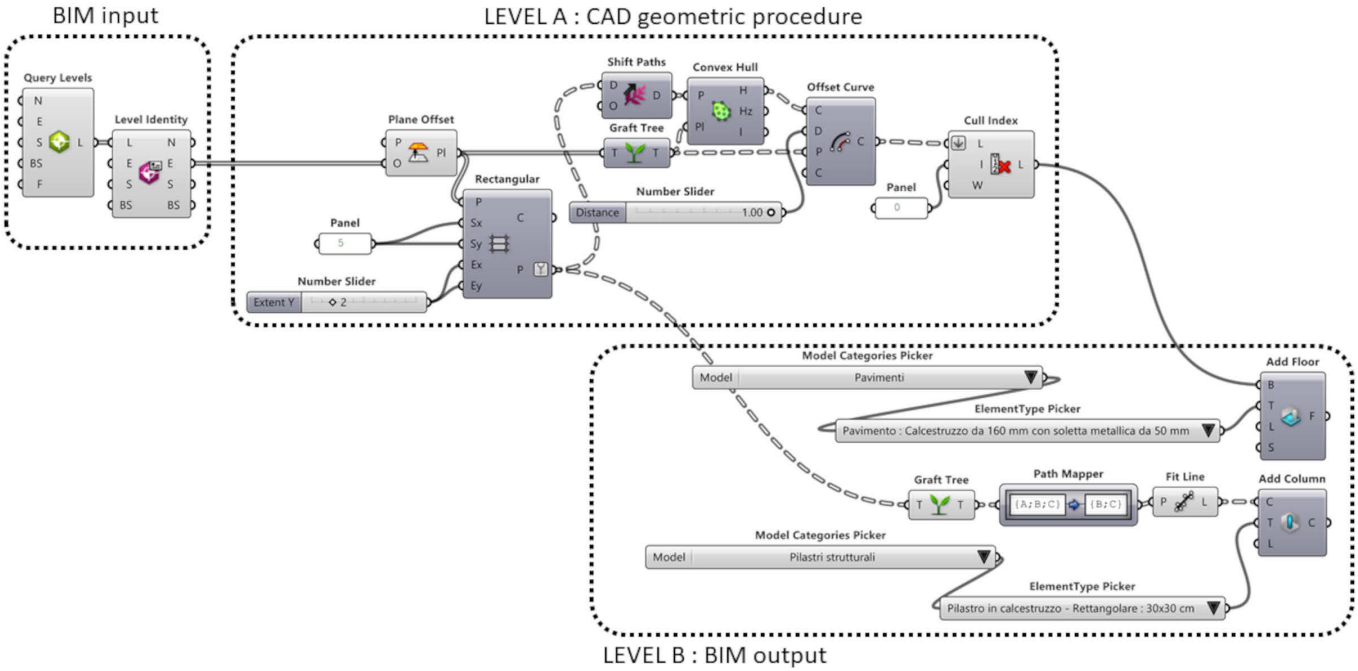


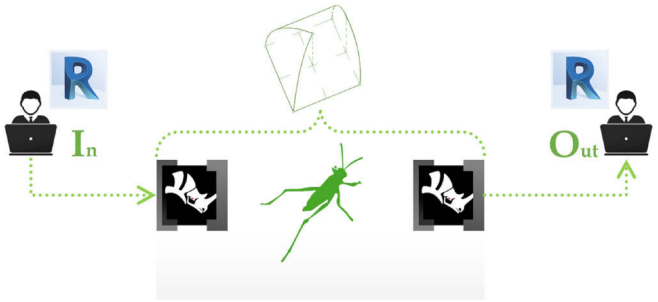
Fig. 3 - Shape grammar for the recognition of the compositional genesis of Villa Malcontenta [Stiny, Mitchell 1978].

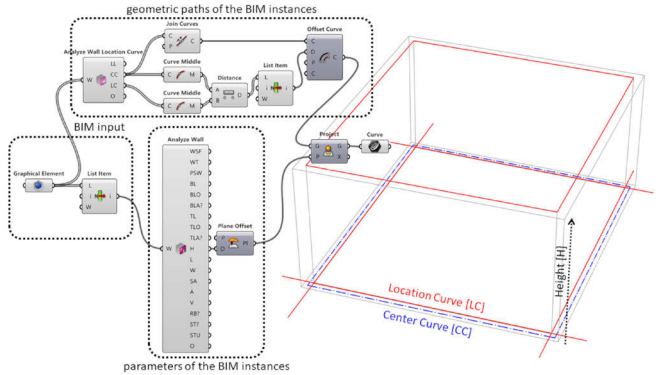
Fig. 4 - Integration of CAD processes into BIM using Visual Programming Language: standard workflows.

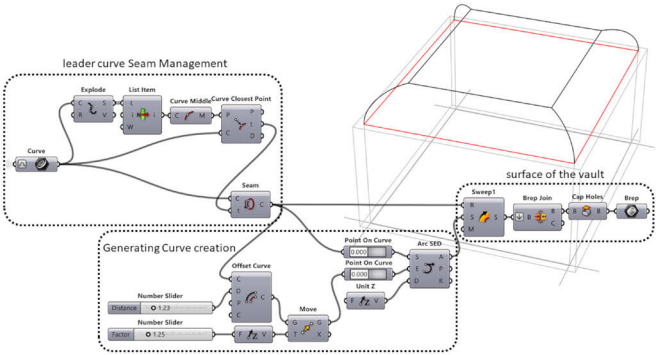
(levels, instances etc.), used to set parameters, transformations and constraints via VPL, which defines the geometric structure of architectural elements and their corresponding model objects. The added value of VPL is the responsiveness of the models created, based on two parametric levels:
Level A - configuring the geometric path and maintaining the relationship between geometries;
Level B - controlling the model objects to be associated with the geometries generated in the previous level.

2.3 Construction of HBIM objects: an example
Historical buildings are characterised by heterogeneity of materials and building systems that have been developed through time and that are not always suitable for standard BIM procedures [Gigliarelli et al. 2017; Radanovic, Khoshelham, Fraser 2020; Stefano Brusaporci, Maiezza, Tata 2018]. Preferred BIM tools are the ones offering optimised parametric modelling and dynamic information query.
Some of BHiLab's[2] experiences test the coupling of BIM authoring tools and VPL[3] to overcome the limits of BIM and automate processes [Gigliarelli et al. 2020] towards a better representation of historical buildings.
Revit divides objects into families, which are classes of geometry and information with a common set of properties and a related graphical representation. Parametric families, although well structured, often do not allow a clear description of the complexity of historical architecture; therefore, to facilitate HBIM representation, tools









that exploit the connection between CAD and BIM can be suitable to couple the descriptive and constructive accuracy of the first to the semantic and informative aspects of the second.

To illustrate the BIM-CAD-BIM interoperability path through algorithmic operations in VPL, we show the modelling of a recurring element of historical architecture, the pavilion vault, that is not a native building element in *Revit* and therefore needs a dedicated process to get to an adequate representation of its shape and stratigraphy (fig. 5). The first part of the definition queries selected instances in *Revit*, extracting their geometric paths. To determine the vault's curve, we can start either from the wall objects that surround the vaulted room or from the shape of the room itself, if included in the model. The first method involves the identification and extraction of walls' location lines; wall objects are then deconstructed in their geometric and relational components. The extracted lines are joined in a closed curve constrained to the walls' upper constraint (fig. 6).

The *Rhino.Inside*[4] application expands *Revit* with the CAD capabilities of Rhinoceros software, inheriting the algorithmic potential of *Grasshopper*. The pavilion vault's geometry is defined from the shuttering curve, the radius of the shafts and the dimensions of the upper rectangular surface from the closed curve previously defined from walls (fig. 7).

The result is the creation of an abstract shape (called conceptual mass in *Revit*), placed in the BIM model exactly on the selected walls. In *Revit* this shape (the mass instance) can be the generative form of the 'roof' element, object able to represent a vault (roof instance by mass surface) conveyng stratigraphy and object informations (fig. 8). The second method uses rooms as input and can therefore be applied for modelling several rooms that share common boundaries, which are extracted to define the closed curves used as in the previous case (fig. 9). The two methods both

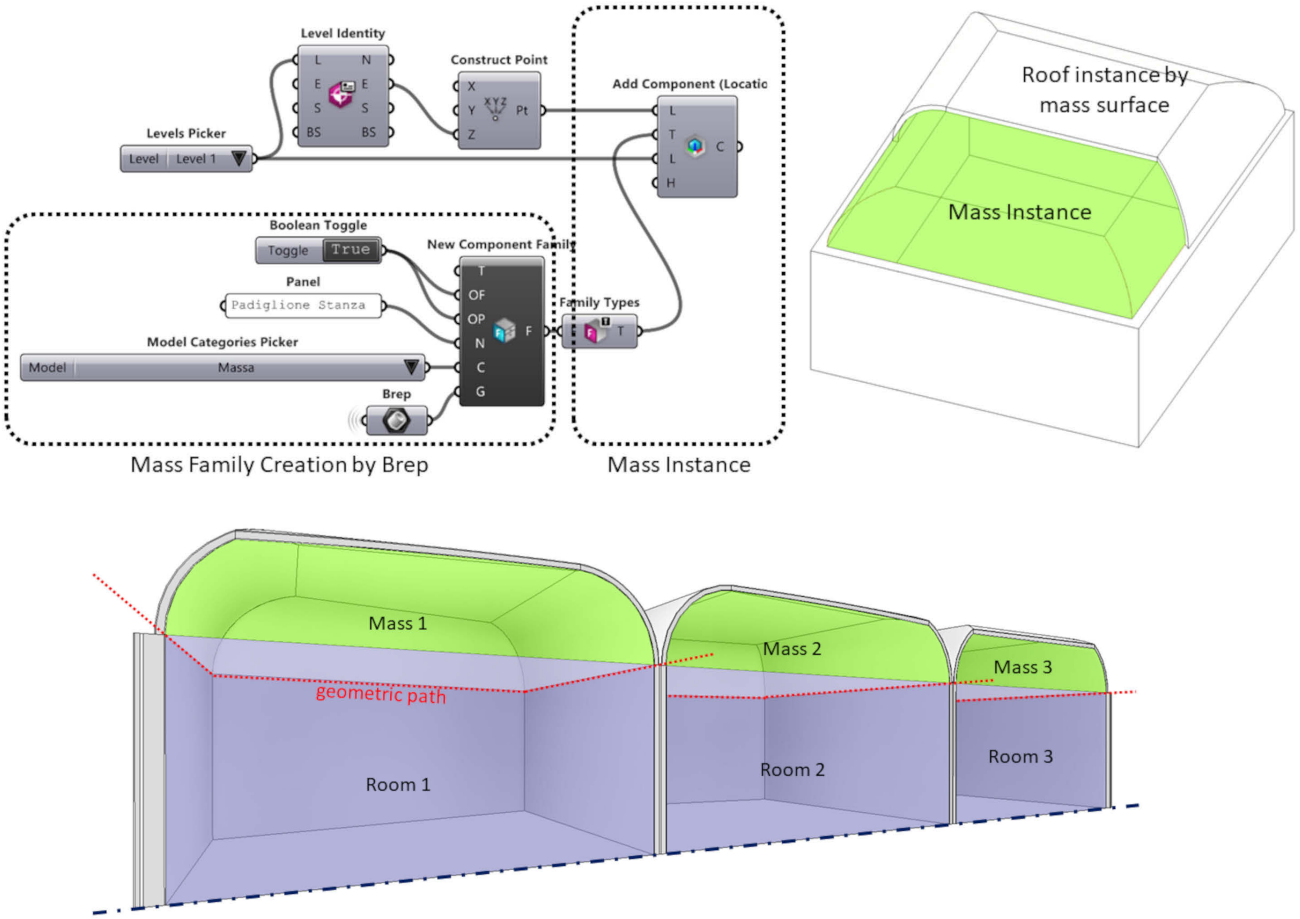


Fig. 5 - BIM - CAD - BIM data flow schematisation using the Rhino.Inside plug-in via Grasshopper.

Fig. 6 - Selection of instances in the BIM environment, extraction of the geometric layout for the construction of the vault shutter.

Fig. 7 - Management of the origin of the closed curve, placing of the vault; drawing of the generating curve of the vault; construction of the geometric mass.

Fig. 8 - Generation of the mass family from bRep, definition of the type into the design environment, application of the roof parametric instance on the mass surfaces for modelling the vaults.

Fig. 9 - Construction of several vaults from the inputs defined by the rooms, if any.

set one-dimensional entities as the input of the object to model, identifying the geometric path as the minimum data useful to trigger the modelling process.

3. Case Study: the Real Sito di Carditello

The workflow was applied to the IDEHA project (Innovation for Data Elaboration in Heritage Areas)[5] coordinated by CNR, and specifically to the Real Sito di Carditello (fig. 10). In particular, the Work Package 2 (OR2) leaded by the BHiLAB, involves the definition of a comprehensive HBIM process from data acquisition to modelling to the integration of both static and dynamic diagnostic data.
The pilot case for the current workflow is a vaulted room acquired through a photogrammetric procedure. The images were taken with a Canon EOS 750D and used for the generation of the point cloud through SfM, which involves the following steps:
- align photos and build a sparse cloud;
- build a dense cloud;
- build a mesh.

Our procedural hypothesis postulates the recognition of geometric paths directly from the sparse cloud. Figure 11 illustrates the result obtained following the orientation of the acquired images, a sparse cloud that densifies in significant places of the room's environment: the edges, the mouldings and the damaged surfaces. Such a sparse cloud, even though equipped with RGB data, does not allow the recognition of the surveyed parts; however, the same SfM software identifies as a sparse cloud the

set of homologous points present in several photos and used for their orientation in the digital space. In the 3D environment of the photomodelling software, the sparse cloud and the oriented photos from which the cloud can be observed coexist. This condition makes it possible to stand at the central point of each photo and identify a series of points that define the relevant architectural signs (paths and points). The advantage of standing on this side of the image is not only the easy recognition of elements but also the automatic projection of the targets onto the sparse cloud by the software (fig. 12). We could say that a sort of topographic survey is being carried out within the photogrammetric survey, where each oriented photo becomes a total station from which to collimate significant points, useful for the reconstruction of the two-dimensional primitives needed to place HBIM objects.
Once the target points are identified, they are exported in a vector format (e.g. .dxf) to be automatically acquired by the VPL code through a component that reads the entities in the directory where the file is placed. In this case study, the points are grouped according to their common height and interpolated by three different polylines: the ground path of the base of the walls, the elevation path of the vault shuttering and the path of the upper rectangular edges of the vault. The last two paths, providing further information on the shafts, determine the geometry of the vault which, using Rhino.inside, is classified as a mass in Revit, on which a roof with correspondent stratigraphy and information is applied.
With the same procedure, in the 3D space of the photogrammetry software, the points representing the insertion points of doors and windows are identified and enriched with metadata (fig. 13), to be recognised in Revit. The corresponding doors and windows have been modelled following a visual and geometric survey to select the constraints and parameters to define appropriate families and types. The VPL code developed with Grasshopper identifies the insertion points, reads

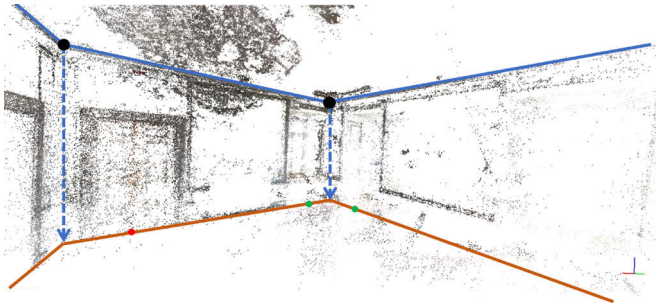


Fig. 10 - Point cloud of the Real Sito di Carditello produced with Structure from Motion process using images taken by a drone.

Fig. 11 - Outline of the geometric paths to be identified in the sparse cloud. The geometric paths will be used to locate the architectural instances in the BIM environment.

Fig. 12 - Collimation of significant points in the 3D space of the photogrammetric environment for the vector drawing of the geometric path.

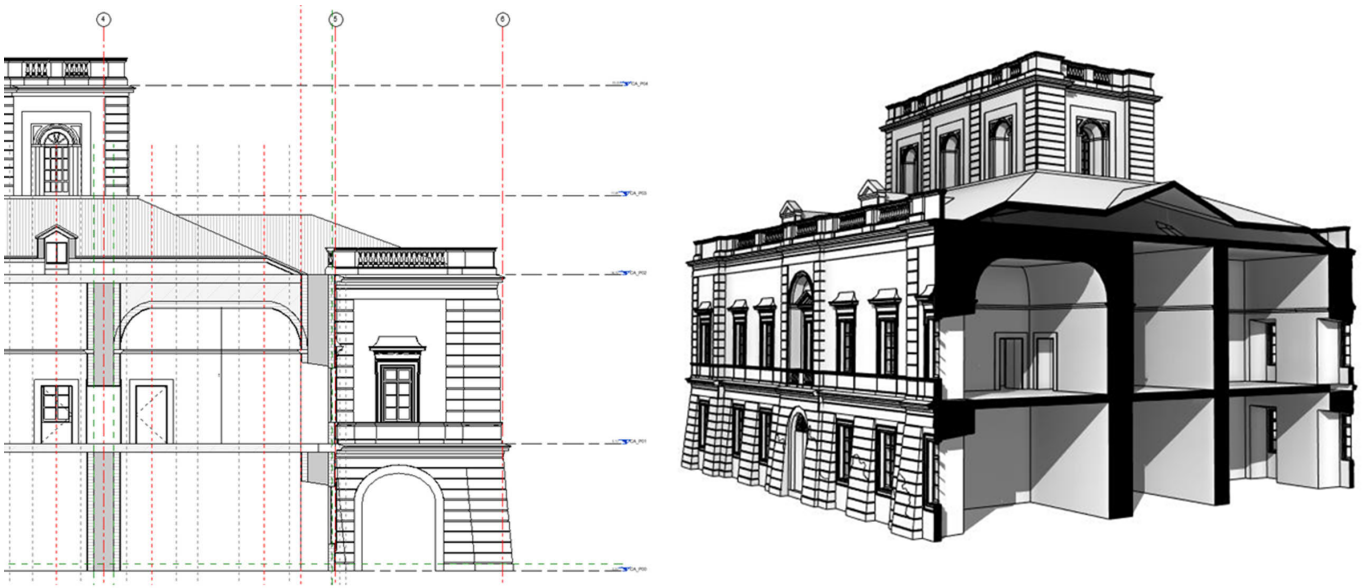


Fig. 13 - BIM model of the main building of the Real Sito di Carditello: the vaulted room has been modelled with the illustrated procedure is visible.

the associated metadata and recognises it as a door or window trace, where the correct doors and windows are automatically placed.

4. Conclusions

The workflow described allows selecting, within a Scan to BIM process, the most significant data from the complexity of information provided by a point cloud. The quantity of survey data, increasing with the evolution of the acquisition tools, is often excessive compared to the needs of BIM modelling processes. The illustrated work clearly shows how the inputs of the parametric objects of an HBIM model are also satisfied by a topographic approach. A critical/selective attitude when working remotely and not in the field, through a 360° overview of the model, allows an adequate tracing of the primitives to place and define HBIM objects.

This traditional awareness is returning at a time when BIM procedures force semantic clarity and constructive representation, bringing back the analytical approach towards architectural forms; an awareness that was being lost when the descriptive process of the surveyed forms ended with the construction of the polyhedral model from the point cloud, where the resulting mesh, although textured, was nothing more than a digital veil, more or less refined, capable of restoring the 3D silhouette of the real models.

The next steps of the research are aimed at defining tools that combine the current workflow with a 3D annotation software developed within CNR: a new application, desktop or cloud-based, to visualize the reality-based model produced by the survey and enrich

it with textual annotations but also with metadata paths, according to a designed information mask; the data inserted, following defined ontologies, will be easily translated in the BIMxs environment as parameters to be associated with the model objects placed on the traced geometries, a 'pop-up' process that will allow the translation of the annotated geometric path into an informed parametric model.

Notes

1. EN ISO 19650-1.

2. Built Heritage Innovation Laboratory of the ISPC conducts applied research in the fields of knowledge, documentation and evaluation of archaeological and architectural heritage, regeneration and valorisation of monuments and historic centres, promotion and communication of cultural heritage through innovative multimedia technologies; Elena Gigliarelli is in charge of the Laboratory's coordination.

3. For the case study presented in this section (§3), we experimented with the BIM-CAD-BIM relationship using the Revit and Rhinoceros connection provided by Grasshopper and Rhino.inside to test one of the newest software technologies in AECO.

4. Rhino.Inside is a technology developed by Robert McNeel & Associates that allows embedding Rhino 7 into other applications. Rhino.Inside is also being embedded into Revit. Rhino.Inside.Revit is an addon for Autodesk Revit that allows Rhino 7 to be loaded into the memory of Revit.

5. Research funds PON - Research and Innovation of 2014-2020; lead institution CNR, Costanza Miliani, ISPC Director, is the project coordinator, Elena Gigliarelli OR2 scientific coordinator.

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PART II

Giovanna Spadafora

Roma Tre University

Massimiliano Lo Turco

Politecnico di Torino

Giovanna Spadafora, architect and Ph.D. is an Associate Professor (Full Professor as of May 2021) of Drawing and Survey, Department of Architecture, Roma Tre University. She is vice-coordinator of the Ph.D. program *Architecture: innovation and heritage* and vice-coordinator of the RilTec (Laboratory of Survey and Digital Technology). She coordinates research on methodologies and tools for urban, architectural, and archaeological surveying, and actively studies the relationship between geometry, drawing, and construction. She is a key figure in the research project D-TECH, *Digital Twin Environment for Cultural Heritage*, funded by the Regione Lazio (responsible for WP2 and Tasks 1.1; 1.4; 2.1). She participates in international research projects such as GISCAD-OV *Galileo Improved Services for Cadastral Augmentation Development On-field Validation* (H2020-SPACE-EGNSS-2019) – responsible for Task 4.3 – and OCSHC, *Oriental Cuba Smart Historical Centres*, funded by AICS (Italian Agency for Development Cooperation).

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He conducts research in the field of digital architecture survey and modeling.
He has been dealing for years in analyzing the capabilities of Building Information Modeling and Visual Programming Language applied to Cultural Heritage.
Principal Investigator of the *BACK TO THE FUTURE* project, developed together with the Museo delle Antichità Egizie di Torino, to define new methodologies in which the Information Modeling tools can be used for unconventional purposes, to realize 3D databases of small objects, especially those belonging to large museum collections.
He is Program Director of the Bachelor's Degree in Architettura/Architecture of the Politecnico di Torino since 2018.

THE USE OF DIGITAL MODELS BETWEEN KNOWLEDGE, INVESTIGATION AND DISSEMINATION

Giovanna Spadafora, Massimiliano Lo Turco

Reflecting on the topic of knowledge and its ensuing communication, articulated in the context of cultural heritage, means participating in the debate that for decades, uninterruptedly, describes the pervasiveness of the digital medium as a trigger for profound social and cultural changes. with significant repercussions in learning, in work, and in the daily aspects of our life. The considerations that also emerge in other sectors of culture help us to evaluate how, as heritage architects, we can contribute to governing and guiding change, working within the flow of the transformation taking place.

In particular, the ways in which we acquire and produce new knowledge share the assumption that the digital model must be configured not only as a final result but also – rather, above all – as an instrument.

Inasmuch as it is the result of our work, be it a survey or project, the digital model itself becomes heritage: an immaterial copy of the material asset, acquires its own autonomy, even figurative, and in either case it becomes memory; but the aspect on which we must continue to work, also in line with the indications of the European community[1], is the refinement of the model as a working and sharing instrument, a privileged site in which acquired data is to be collected and systematized. The model as an instrument is therefore a container of data whose quantity, in some way inevitable and consubstantial with the digital methods of acquisition themselves, acquires meaning the moment it is possible to deduce information from them. If these can be linked with others, the model thus configured contributes to broadening our knowledge. In its being deployable, and thus in continuous transformation, the model becomes something organic, continuously becoming[i2]; but this implies, upstream, setting up a workflow that allows the sharing of processes.

We could therefore say that digital models, whether they be copies of real objects or reconstructions made from drawings or paintings, are now also configured as "infomata", but that the neologism coined by Byung-Chul-Han[3] may assume, in the field of cultural heritage, a predominantly positive meaning, in those activities whereby the creation of new meanings and new narratives can derive from the correlation of information. Indeed, it is relationships that transform information, "discontinuous and additive elements", into knowledge. This puts at the core of our reflections the issue of ethical responsibility inherent in selecting data and information and in structuring metadata to be shared.

It is, therefore, necessary to continue to question what rules must or could be able to guarantee the sustainability of the digital ecosystem in the field of cultural heritage, beginning with the data acquisition phase.

The topics covered in this session concern the use of the digital model as an instrument of knowledge, investigation and dissemination, and that of computational graphics applied at various scales and purposes. What unites all the interventions is

the reflection on the different ways in which space can be studied and observed through digital media, contributing to the creation of new knowledge: the real, the mathematical, the painted space, and the space represented through two-dimensional drawings.
The first contribution of the session, curated by Martino Pavignano, relates the applicative interconnections between Mathematics and Architecture, between research and teaching. As Guarino Guarini argued, the architect must know the rudiments of geometry since architecture is based precisely on this science, intended by the Master to be a specific declination of mathematics. The experience carried out by the author between physical and digital modeling is useful in identifying multiple ways of understanding and representing architectural forms, recovering and rediscovering common themes in the disciplines involved, where the process is primarily characterized as an instrument of knowledge.
The work by Francesca Gasperuzzo avails itself of the digital survey and the following reconstructive digital modeling activities, efficiently using them as tools for verifying the "oblique design system" theorized by Juan Caramuel de Lobkowitz in his architectural treatise *Architectura civil recta y obliqua* for the facade of the Vigevano Cathedral. The ensuing result is an in-depth analysis carried out of the drawing and through drawings and surveys, to highlight the possible geometric design reasons that led the Bishop to conceive such an unconventional work.
Matteo Flavio Mancini speaks of algorithmic models to describe an analysis methodology applied on a completely different scale, that of cultural landscapes. In this case, the model – algorithmic – is used to study the visual relationships, which could be recovered as part of an enhancement project, that have linked the various urban settlements in the area west of Lake Bracciano (Rome).
The intervention by Francesca Porfiri concerns the theme of the normalization and integration of the data that over time have been acquired regarding the Arch of Titus, emphasizing the value of the qualitative survey, that is, direct observation and analysis of the sources, as a guide to work within the myriad of points derived from the digital survey. That is, having an overall view and knowing how to identify the details.
From the architectural detail to the pictorial detail: Giulia Piccinin reasons on the classification and organization of data and their reciprocal relationship by working on the analysis, acquisition, and interpretation of a sixteenth-century pictorial cycle decorating the headquarters of the Scuola del Carmine in Padua. The preparation of an interoperable and semantically structured database constitutes at the same time a fertile ground for the creation of multimedia tools, allowing navigation and querying of the organized semantic model.
For the in-depth analyses that characterize them and for the questions they pose to our reflections on the role of the digital in our work, the various interventions seem to

fulfill the desire that Massimo Mantellini expresses in the last lines of his book *Bassa risoluzione* (*Low resolution*), that is: "We should imagine a point of intersection between surface and depth, between our desire to gently fly astride technology and the obstinacy of that painter [referring to Domenico Gnoli] who painted a button. Only the two things together can tomorrow be what we once called culture: both, indissolubly united, will tomorrow be what we will continue to call culture."[4]

Notes

1. See, for example, the final report of the European Commission VIGIE 2020/654 *Study on quality in 3D digitisation of tangible Cultural Heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines*.

2. Thus Ludovico Quaroni speaks of the city, which was once considered something "alive, continuously mobile, to which something could be added or removed as long as it was made by hands that 'felt' the organism in its living". See Quaroni L. (2019). *I volti della città*. Roma: Edizioni di Comunità, p. 16 (*The faces of the city*). From this point of view, we can therefore observe how real objects and digital copies are transformed with different rhythms and circumstances: the first, slowly, from the material work of man and time, the latter, with greater speed change in content and in relationships.

3. Byung-Chul Han argues that "computerization of the world transforms things into 'infomata', that is to say agents that process information": Byung-Chul H. (2022). *Le non cose. Come abbiamo smesso di vivere il reale*. Torino: Einaudi Stile Libero Extra, p. 4.

4. Mantellini, M. (2018). *Bassa risoluzione*. Torino: Einaudi, p.130.

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His scientific interests deal with historical architectural drawing and survey, critic analysis of the connections between drawing, images and texts in historical architectural librarian production/ press, interactions between architectural shapes, design and Geometry. UID adherent fellow.

07 MODELS FOR GEOMETRY: THOUGHTS FOR AN INTERDISCIPLINARY DISSEMINATION

MARTINO PAVIGNANO

Abstract

The contribution proposes a series of methodological reflections aimed at the knowledge and enhancement of the models of mathematical surfaces preserved in the Collections of the University of Torino, as expressions of cultural assumptions that allow us to understand Geometry as a language and connection tool between Architecture and Mathematics. These artifacts, over time, have made their geometric assumptions tangible so that, to date, a critical reinterpretation is proposed aimed at their reinterpretation, including digital, as the first design step of their renewed prototyping.

Il contributo propone una serie di riflessioni metodologiche tese alla conoscenza e alla valorizzazione dei modelli di oggetti matematici conservati presso le Collezioni dell'Università di Torino, quali espressioni di presupposti culturali che permettono di intendere la Geometria quale linguaggio e strumento di connessione tra Architettura e Matematica. Tali artefatti, nel tempo, hanno reso tangibili i propri presupposti geometrici tanto che, ad oggi, se ne propone una rilettura critica finalizzata alla loro reinterpretazione, anche digitale, quale primo *step* progettuale della loro rinnovata prototipazione.

Foreword

The contribution proposes a thought on a methodology for the valorisation of physical models for the study of geometric surfaces belonging to museum heritage ff the University of Torino. They are preserved at the "G. Peano" Library (Dept. of Mathematics) and their interest arises stronger even due to the needs highlighted in the historical period that started on the first months of 2020. This thought affects both the accessibility of this heritage, as well as its dissemination to a heterogeneous unspecialized public, also in response to Third Mission actions of the two Universities involved.
The interest in these artifacts arises within the MAG. IA interdisciplinary research project, based on the effective collaboration between the disciplines of Architecture and Mathematics, in the respective declinations of Drawing (Icar/17) and Geometry (Mat/03). It focuses on the recognition and critical analysis of Geometry as a shared language, which can also be used as a tool for the enhancement of heritage (architectural and otherwise).
In this sense, it is important to remember that Guarino Guarini, architect, and mathematician, upheld the fundamental importance of Geometry for Architecture [Guarini 1737, p. 3], to be considered the result of a process of interpretation of mental models geometrically analysed and defined [Leonardis 2016, pp. 93-94], or expression of forms of representations based on the geometric foundations of Descriptive Geometry [Bianchini 2008, pp. 27-28].
In these terms, the MAG.IA project refers to the fundamentals and specific declinations of Geometry as possible interpretative expressions [Migliari 2009; Gay 2000; Giaquinto 2007; Friedman 2018] of two different ways of analysing, describing, and representing the world.

State of the art

Once defined the specific cultural and disciplinary context, it is necessary to promptly highlight the value attributed to the idea of tangible model in its primary essence as physical artefact, built starting from a project. To this end, in the interdisciplinary spirit of the project, a reinterpretation on two levels is proposed: both in the role of tangible artifact, created to facilitate the study and visualization of abstract concepts, in the purely mathematical declination [Giacardi 2015], as well as in the role of medium for the dissemination/ enhancement of cultural heritage, through its reduction 'to scale' [Cumino et al. 2021]. In this sense, the most recent thoughts developed within the research project led to consider the physical model as the result of a figurative path of eidetic nature: sometimes it is speculative, but it is always recognizable as an artifact of great value (not only historical) for both Architecture and Mathematics [Cumino et al. 2020]. In the first case (fig. 1), Massimo Scolari analysed the different values the physical model gained, referring to the process of morphological transformation that saw its meaning shifted from that of a votive icon to that of a validation tool for the project, closely linked to the libido edificandi. Nevertheless, A. Smith specified its essence as a fundamental "machine" for "mediating between divine chaos and humanity's cosmos" [Smith 2004, p. 122]. Likewise, for the mathematical context (fig. 2), Marcs D. Giaquinto confirmed the epistemolog ical role assumed by the physical model in the field of Visual Thinking for Mathematics [Giaquinto 2007], clarifying its function of material projection. Moreover, Michael Friedman highlighted the role of the physical model for the study of Geometry in Klein's view "to understand the relations valid for them as evident consequences of the principles of spatial intuition" [Friedman 2018, p. 123].

Fig. 1 - Architecture and models: from symbolic to analytical function. Theatrical scene, I cent. DC; Fortress of Zara, plan relief, 1566; Domenico Cresti, Michelangelo presenting his model of San Pietro to the Pius IV, 1618-1619; Antoni Gaudì's study strings and weights model, XIX cent. first quarter [Scolari 2005; Smith 2004].

Fig. 2 - Mathematics and models: Fabre de Lagrange's string surface models, 1872 (Royal Society 2012).

Object of study

The collection of models of mathematical surfaces of the Peano Library (fig. 3) was born at the behest of the mathematician Enrico d'Ovidio between 1880 and 1881 [Giacardi 2015, p. 22; see also Giacardi 2004], following the remarkable success received from such artifacts at the academic level following the early works of Felix Klein and Alexander von Brill [Seidl 2018], that gained the favor of the scientific community also thanks to the functional inclusion in specific technical Catalogs [Pavignano et al. 2020., pp. 3661-3662]. The collection accounts about seventy models made with different techniques: brass and silk threads, plaster, glass, cardboard. The same techniques correspond to different possibilities of interpreting the artifacts, since the wire models highlight ruled surfaces, the plaster ones, as well as the glass sets, emphasize the overall nature of surfaces, while the cardboard models represent them using their notable sections. Some mathematical objects are therefore present in two or more types, as discussed later.

This heritage is currently recognized as an expression of that scientific/mathematical culture of a positivist nature which has its roots in Monge's successors' studies on Descriptive Geometry [Moon, Abel 2016; Gay 2000].

Since the end of the 20th century, the scientific community became aware of the importance of this heritage, starting to investigate their value of material expression of mathematical culture of the time [Palladino, Palladino 2001; Ferrarese 2004]. Meanwhile, following the success of digital tools, i.e. ray tracing software [see Sdegno 2004], collections of virtual alter egos were created. In the case of the UniTo models, numerous digital artifacts were created with PovRay (fig. 4) and published online by Professor Ferrarese (early 2000s and still accessible).

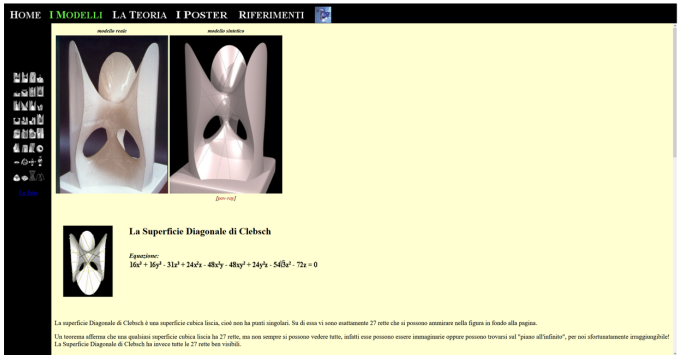
Regardless of the possible digital interpretations, the UniTO heritage is currently not easily accessible. In fact, this collection is kept in the archives of the Peano Library (fig. 5), thus being available only to authorized scholars. Moreover, a general public may encounter difficulties in analysing its in-depth use (or not only aesthetic) due to the requirements for specific knowledge.

The models were created with the primary purpose of visualizing abstract objects, studying their peculiarities, but, even if they have already been recognized as a heritage, they often have been interpreted as Wunderkammer objects, even though they were subjects of those "didactic theaters" which were an integral part of technical and polytechnic culture [Gay 2000, pp. 43-47].

This research, however, aims at placing the main geometric values of these objects in the foreground, since they are configured both as the result of a process of analysis of mathematical entities, and as the result of a real process of communication and visualization of the same. Furthermore, they can become the basis for renewed types of communication of Geometry, between Architecture and Mathematics. since it is known that this kind of heritage, once was a harbinger of interesting ideas for the renewal of architectural form, within the modernist architecture and not only [see Vierling-Classen 2010; Farinella, Baglioni 2018; Greco et al. 2018]. Thus, it is also important to summarize the main features that allow a possible definition of recognized interdisciplinary heritage, between the two disciplines.

In this regard, we take exemplify the practices of enhancement/communication already developed in the Italian and international context, where important collections the are variously exhibited online. I.e. Universities of Pavia, Naples Federico II, Padua; University of Coimbra; Institut Henri-Poincaré, Museum of the University of Tübingen; University of Arizona; Smithsonian Institution and Univestity of Illinois (fig. 6) provide different accesses to their specific heritage.

In all these cases, it is possible to recognize a great attention for the mathematical interpretation of these



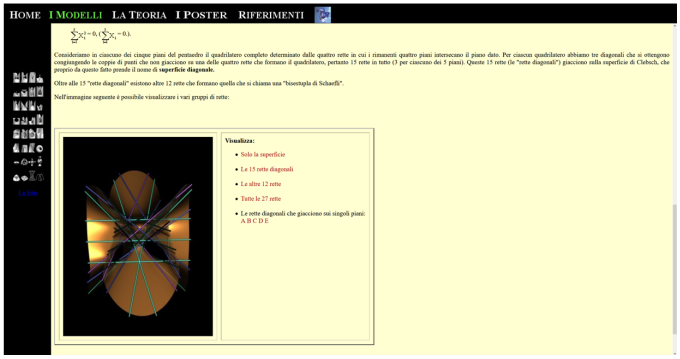


Fig. 3. Selezione di modelli della collezione UniTo (M. Pavignano 2020).

Fig. 4. Digital collection of models of the Biblioteca Peano.

artifacts, mostly thanks to the use of formulas to represent the geometric realities of models, with specific interests for the need to 'shaping' an abstract idea, while defining the contours regarding the production of aids for the teaching of mathematics for mathematicians. In this sense, there is little interest in the 'structural' substance of these products, which can be defined as the results of semi-artisanal processes that clearly avoided the need for numerical control of the representation, thus declined in the form of symbolic elaboration of shapes.

In this sense, it is important to underline that these products are closer to called unique pieces [see Bortot 2019].

In this direction, the project raises questions relating to the dimension of the enhancement of the concept of shared heritage and the documentation of the cultural values of which these artefacts are bearers.

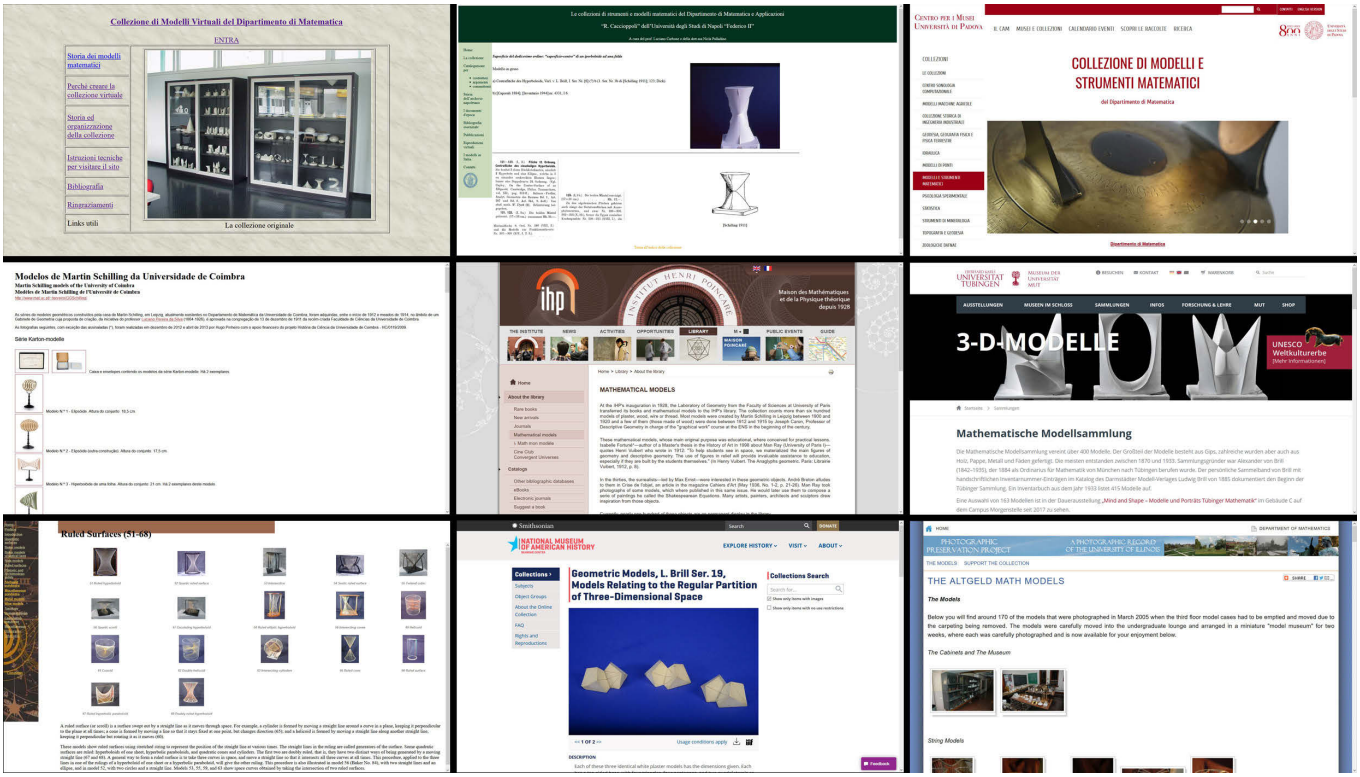


Fig. 5. Display cabinets for models' presentation at the Biblioteca Peano (M. Pavignano 2020).

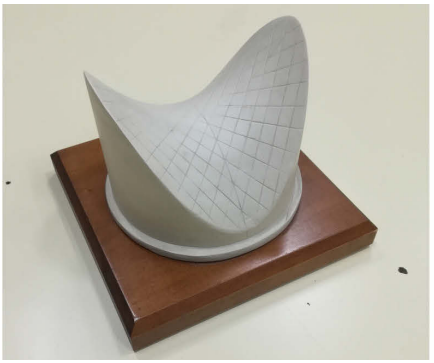
Fig. 6. Examples of collections of models on the web.

Methodological process

We then structured the methodological process by identifying a model that was represented in the greatest number of types. This model is the hyperbolic paraboloid (fig. 7), a surface of great interest for both disciplines [see Inzerillo, Di Paola 2012]. Obviously, the three models do not represent the exact same surface, nevertheless they propose three different interpretations. The string model highlights the nature of the ruled surface, in addition to the notable parabolic and hyperbolic sections; the plaster model, whose surface is engraved with portions of the (infinite) generatrixes, emphasizes the continuity of the surface by offering as a valid, even if not explicit, synthetic representation. The third model shows vertical parabolic sections, integrated by the

traces of one horizontal hyperbolic section proposes an extremely limited reinterpretation, since the viewer must fulfil the virtual reconstruction of the surface by himself. On the other hand, it is important to emphasize that the third solution presents itself as the simplest to be reproduced.
This analysis highlights how the different models communicate the same geometries in a different way. The degree of approximation with which they were made does highlights the need of a proper survey, at least for the main purpose set out here. In fact, the feasibility for a subsequent development of the project is not excluded. These three models highlight a fundamental aspect of their conception, in fact we express the choices made for the material discretization of the represented surface which, in the intent of the proposed study, can support the definition of renewed critical interpretations of these prototyping processes.
Another possible implementation is the construction of digital artifacts modelled with Dynamic Geometry Software, which make possible the coexistence of the visual representation of the object and its clearly mathematical analytical description (fig. 8), defining an interactive and easily implementable tool.

The same surface can digitally represented with CAD software (fig. 9). These models become tools for direct exploration the object and for prototyping it into a tangible artefact. We investigated the possibilities of laser cut and 3D print. In both cases, we started with the definition of the digital model and its subsequent elaboration for the creation of models for vertical and horizontal sectional planes in vegetable cardboard, or for the creation of solid models in PLA (fig. 10).
These artifacts represent a reinterpretation of models of the Peano collection and highlight their geometric characteristics by integrating the original weaknesses by means of an interaction made possible by our design choices. The models, in fact, have been created to facilitate mutual interpenetration, by proposing complementary physical representations.
Models were used during the events linked to the European Researchers' Night 2020, thus becoming mediated by the digital medium and setting up a series of short documentaries and subsequently made available on social network platforms (YouTube).
The primary purpose of the events was to make high school students participate in the communicative potential of prototyped models, starting from their geometric genesis as ideal prosecution of the functions performed by historicized artifacts.

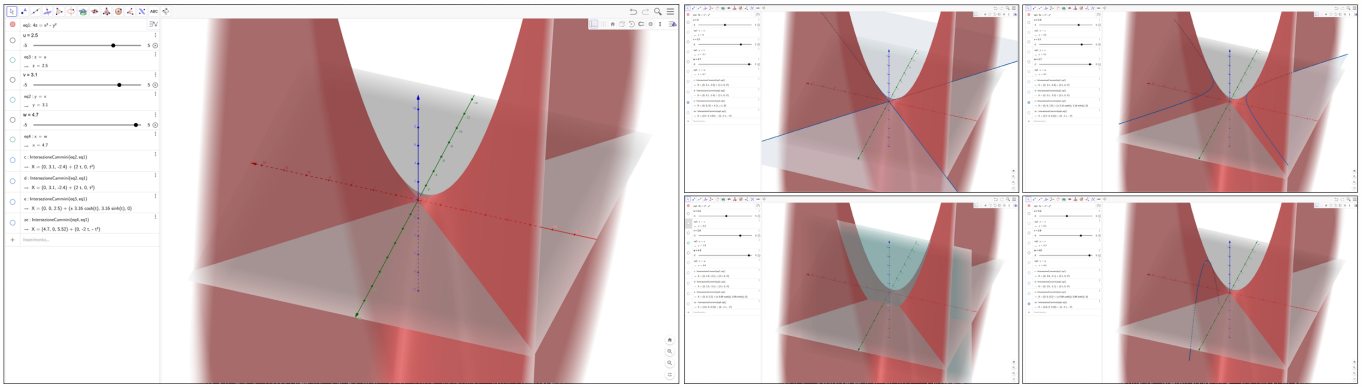
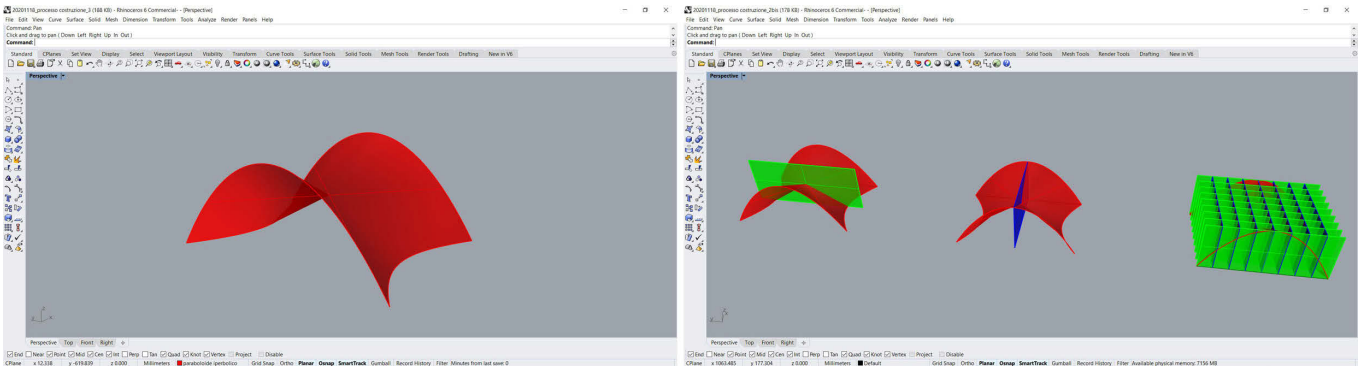
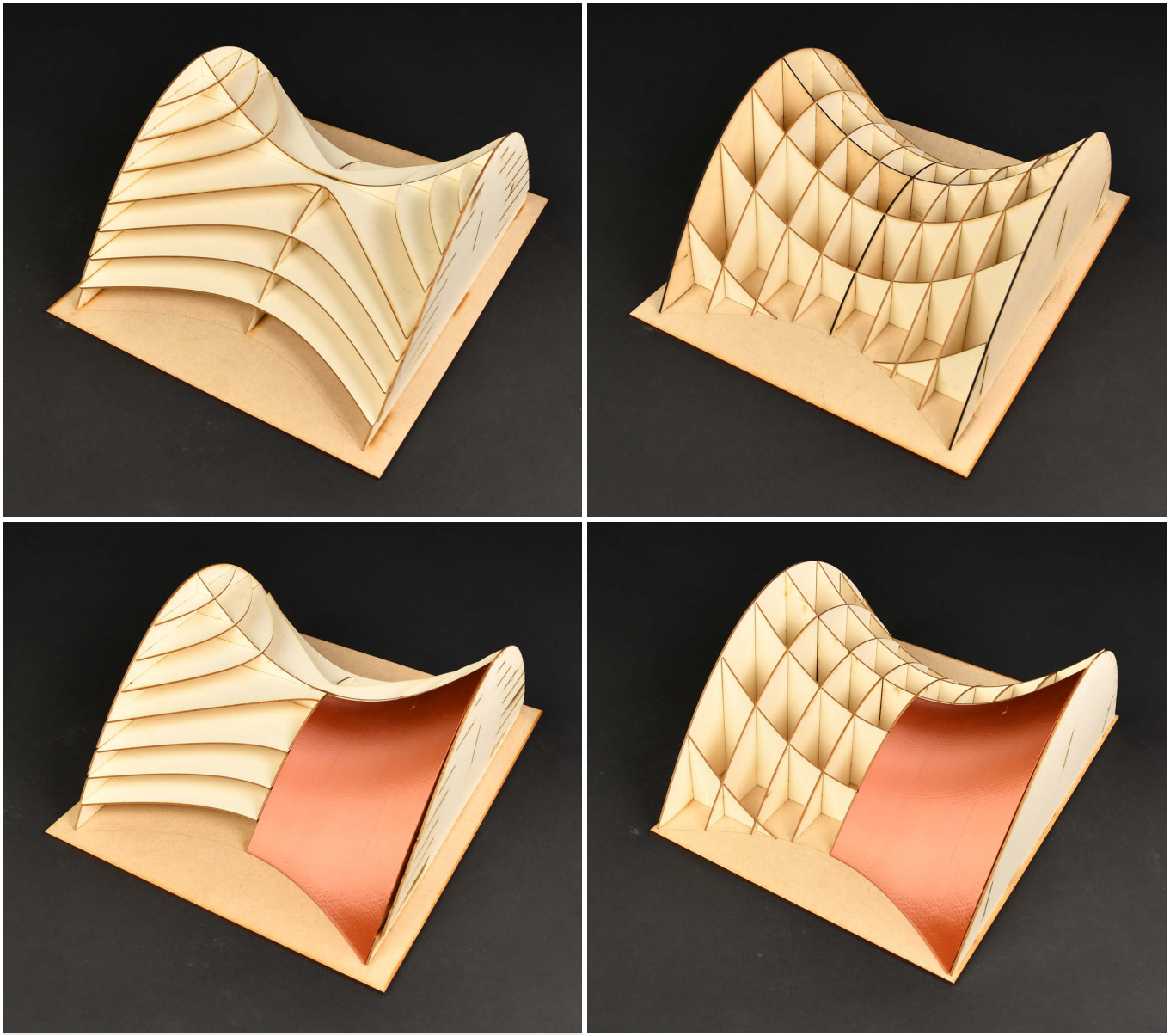



Fig. 7 - The results of the intervisibility analysis at territorial scale from several simultaneous points of view.

Fig. 8 - DGS model describing a hyperbolic paraboloid and its sections (courtesy of C. Cumino).

Fig. 9 - Digital models for communication and prototyping of new models (elab. M. Pavignano).





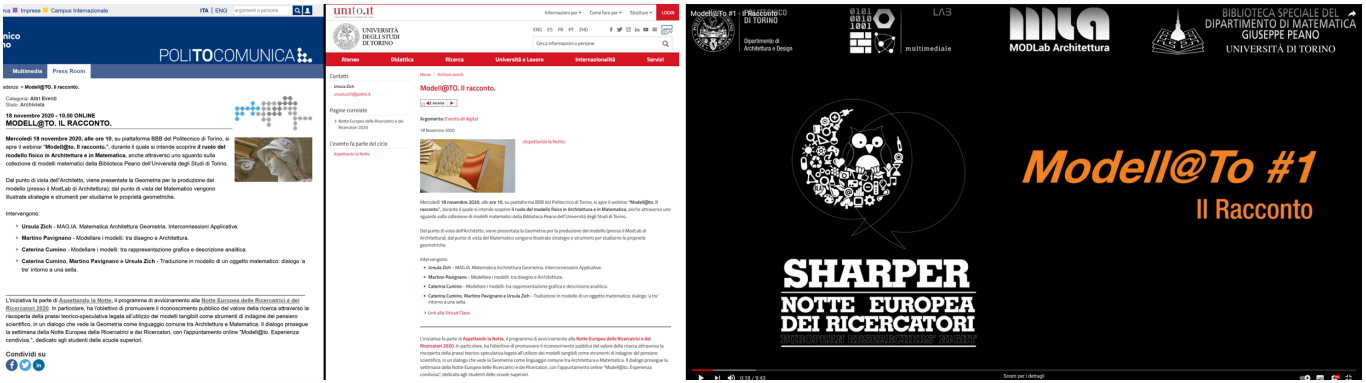


Fig. 10 - Laser cut and 3D print models and their interaction (elab. M. Pavignano).

Fig. 11 - Different possibilities of enhancing models' knowledge and communication: European Researchers' Night 2020 (MAG.IA team).

Discussion and (open) conclusion

The experience discussed clearly aims at defining new supports for the interdisciplinary dissemination (referring to the last two years of high school and first year of university) between Architecture and Mathematics, to support a mutual dialogue.
Therefore, it is clear how this methodology allows an interconnection between the physical model of heritage value, its updated reinterpretation in the light of the possibilities offered by rapid prototyping techniques and their mediation through digital tools. Furthermore, paraphrasing what Graziano Mario Valenti asserted [Valenti 2019, p. 47], it is again highlighted how Geometry, by means of Drawing as a tool of ideation and generation, can manifest itself through physical and digital models. In this sense, through the hybridization of languages and communication methods, it becomes possible to propose opportunities for the active enhancement of a shared heritage, as the bearer of specific geometric characteristics useful both for the definition of its mathematical properties, as well as possible suggestions for understanding of complex architectural postulates.

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Notes

1. *Mathematics Architecture Geometry. Interconnections and Applications*. 2018-on going.

2. <www.toonz.com/personal/todesco/superfici_algebriche/index.html> (last accessed August 18 2021).

3. <www.unito.it/eventi/modellto-il-racconto> (last accessed August 18 2021).

4. <www.youtube.com/watch?v=zxiHU1dqJb0&t=76s> (last accessed August 18 2021). In the initial intentions of the project, it was envisaged the possibility of using the models during a series of guided visits to the Peao Library, however this was not possible due to evident limitations linked to the contingent situation.

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He graduated in Architectural Engineering at University of Padua in 2011 with honors. From 2011 he has been exploring theory and practise of BIM and applying it to enhance the building process, particularly for existing buildings. His interests in research involve history of representation methods, application of advanced geometry for AEC industry (e.g., vaulting systems in heritage buildings, architectural façade systems, etc.), open format for BIM management, description of historic transformation with BIM.

08 SCRIPTING GUARINI, CONNECTING TREATISES, GEOMETRY AND REPRESENTATION

PAOLO BORIN

Abstract

Starting from the relationship between knowledge graphically expressed in stereotomic treatises and the concept of scripting in contemporary computational modeling, the paper shows the results of the application of visual programming techniques for cylindrical vaulting as described in *Architettura Civile* (1737), the well-known treatise by Guarino Guarini (1624-1683).

The proposed results simplify the understanding and evaluation of the stereotomic procedures, putting them in relation to those of other Baroque authors.

Partendo dalla relazione tra nozioni presenti nella trattatistica stereotomica e il concetto di scripting nella modellazione computazionale contemporanea, il contributo mostra i risultati dell'applicazione di tecniche di programmazione visuale per le apparecchiature di volte cilindriche presenti in *Architettura Civile* (1737), trattato di Guarino Guarini (1624-1683).

Il risultato prodotto permette di semplificare la comprensione e valutare la correttezza delle procedure analizzate, mettendole in relazione con quelle degli altri trattatisti.

The reputation of Guarino Guarini in the last century has made possible an extensive literature on its figure, not only from a biographical and stylistic perspective but also as a scientist and mathematician of the XVII century. This work aims at exploring Guarini's theory of stereotomy, often described as peculiar to his architectural production, but it lacks a comprehensive investigation. The stereotomy, from the Greek form '*στερεός*', solid, e '*τομία*', cutting, is the science that studies the cutting of solids, generally intended made by stone (as vertical or vaulted architectural elements) or by wood (in terms of beams and columns).

Scholars define stereotomy as a shipbuilding practice turned into a science by famous treatises, in a slow process of abstraction of mechanical operations in rules and systems. However, it has undergone a procedure of sublimation, so Edward Warren specifies, in the introduction to his *Stereotomy Problems In Stone Cutting* (1903), as the stereotomy "embraces, either by etymology, or established usage, subjects and disciplines often distant such as the study of the Theory of Shadows, the Perspective, the Gnomonic, the Cinematics, the iron and wooden carpentry and only finally the "cutting of stone pieces of prescribed form" [Warren 1903].

The main reference for studies on Guarini's stereotomy is the work by Werner Müller who published an extensive study about the origin of Guarini's knowledge on stone cutting [Müller 1968], highlighting a few mistakes and inconsistencies in his *Architettura Civile*.

Alberto Perez Gomez wrote about the relationship between science and art in the work of Guarino Guarini [Pérez-Gómez 1983]. More recently, Franco Rosso suggested a new interpretation of stone shapes in the Chapel of the Holy Shroud [Rosso 2006]. Carlo Bianchini proposed a new interpretation of the Guarini position in the history of representation [Bianchini 2008], based on the translation of the mathematical treatise *Euclides adauctus et methodicus mathematicaque universalis* [1671]. Mark Ericson illustrated digital representation, regarding the relationship between geometric methods and the fabrication of architecture [Ericson 2013].

Guarini does not use the term 'stereotomy', but he refers to "Ortografia Gettata" as "La Ortografia non è altro [...] che una impressione, terminazione, vestigio notato nel piano di una superficie ad esso normale, la quale circondi un'altra elevata dal detto piano; dal qual vestigio così normalmente impresso si conosca, qual parte copra ed occupi del piano medesimo"[1] [Guarini 1737, p. 191].

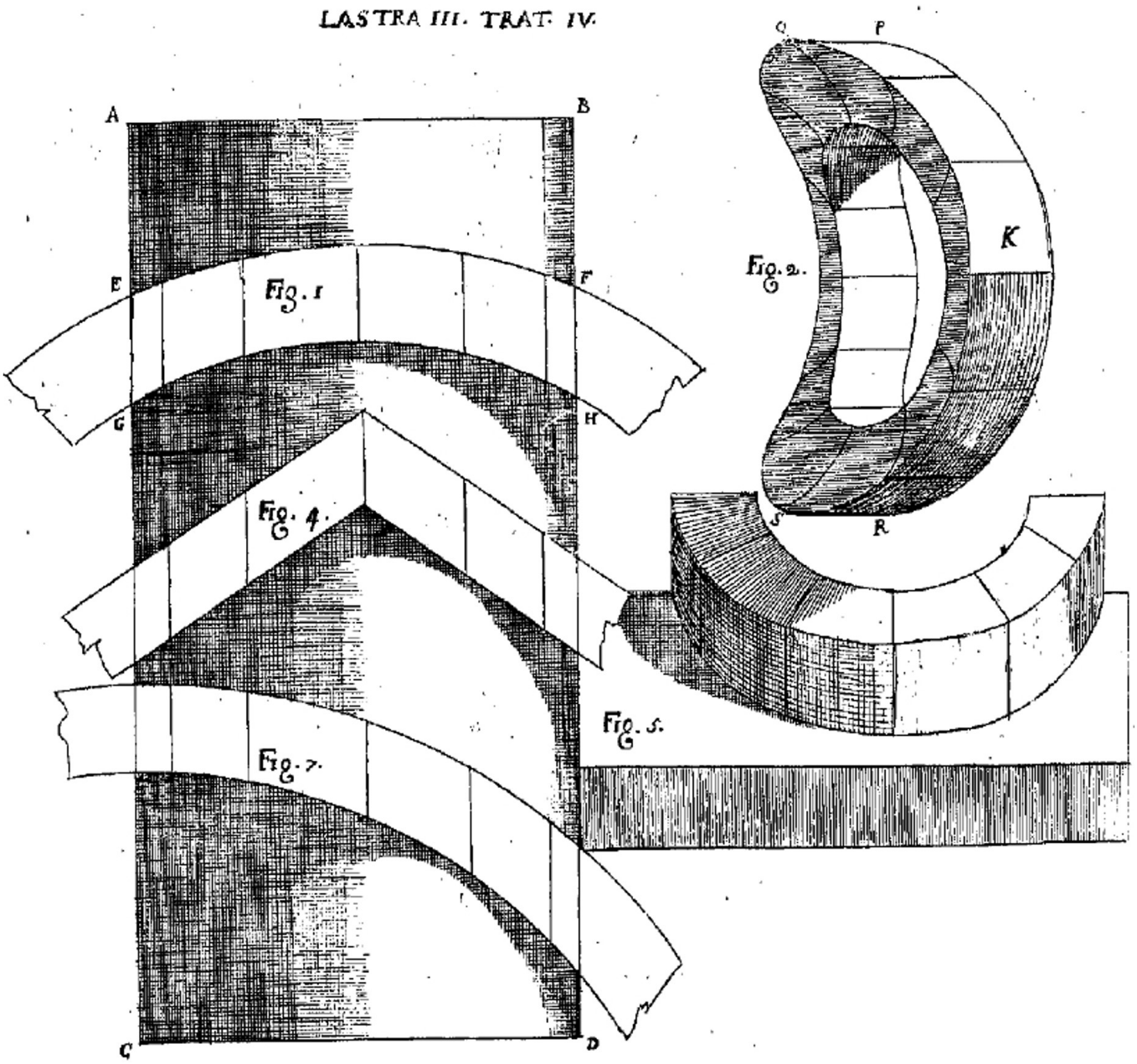
It is useful to map Guarini's vocabulary with the actual terms used in geometric modeling. The verb 'gettare' is intended to project. When he refers to "stendere nel piano", it means the development, as rebatting one smooth surface over another in the Euclidean space. The terms are combined with the expression "*ritrovare la superficie*", to indicate the final step of any stereotomic case in *Architettura Civile*, involving both projection and development operations (fig. 1).

Looking at the structure of architectural treatises, it consists of an organized set of geometric rules. Starting from basic concepts, the authors combined them to configure a system of knowledge, by further steps of growing complexity. The approach is very similar to programming operation because programs are developed around the declation of basic functions, then cited in cycles to perform complex procedures [Davis 2013].

Consequently, the work here presented is the translation of Guarini's instructions through a script. Particularly, to analyze and produce the same information described in the *Architettura Civile*, it has been used a Visual programming Language [2] (fig. 2). The information concerns both 2D drawings, as described by Guarini, and 3D spatial surfaces, such as vaults and arches.

The testbed for this approach is the third chapter

Fig. 1 - Three stereotomic cases involving cylindrical surfaces. Guarino Guarini, Architettura Civile (1737).


LASTRA III. TRAT. IV.
A
B
E
F
G
H
Fig. 1
Fig. 4.
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C
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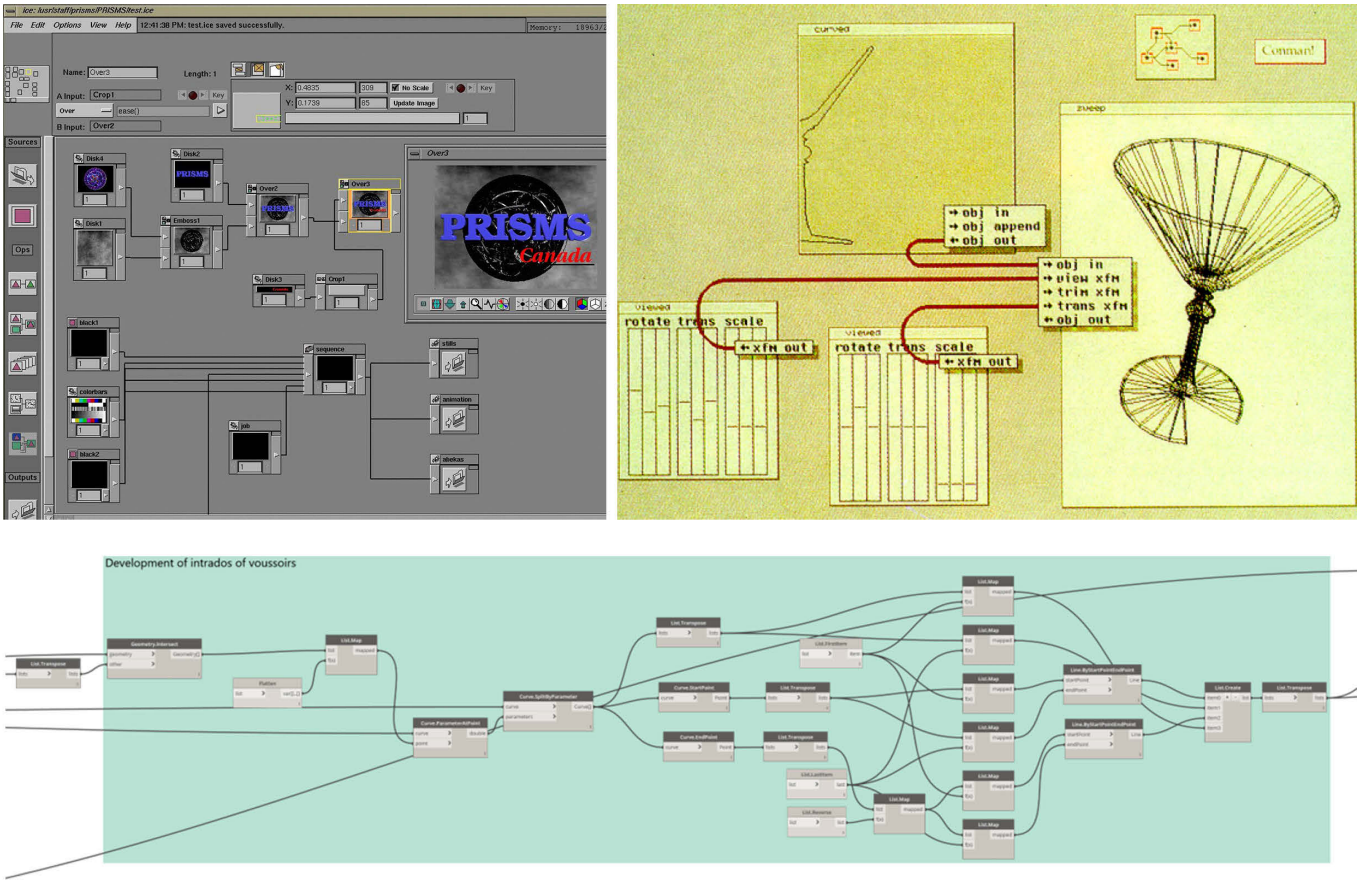

Fig. 2 - In the upper part, the PRISM interface and the ConMan modeling of a Martini glass [Haeberli 1988]. In the lower part, a portion of the script for the development of the intrados surface.

Fig. 3 - On the left, horizontal and vertical projections of cylindrical arcs, on the right, the approximate 3D appearance of ashlars. Guarino Guarini, Architettura Civile (1737).

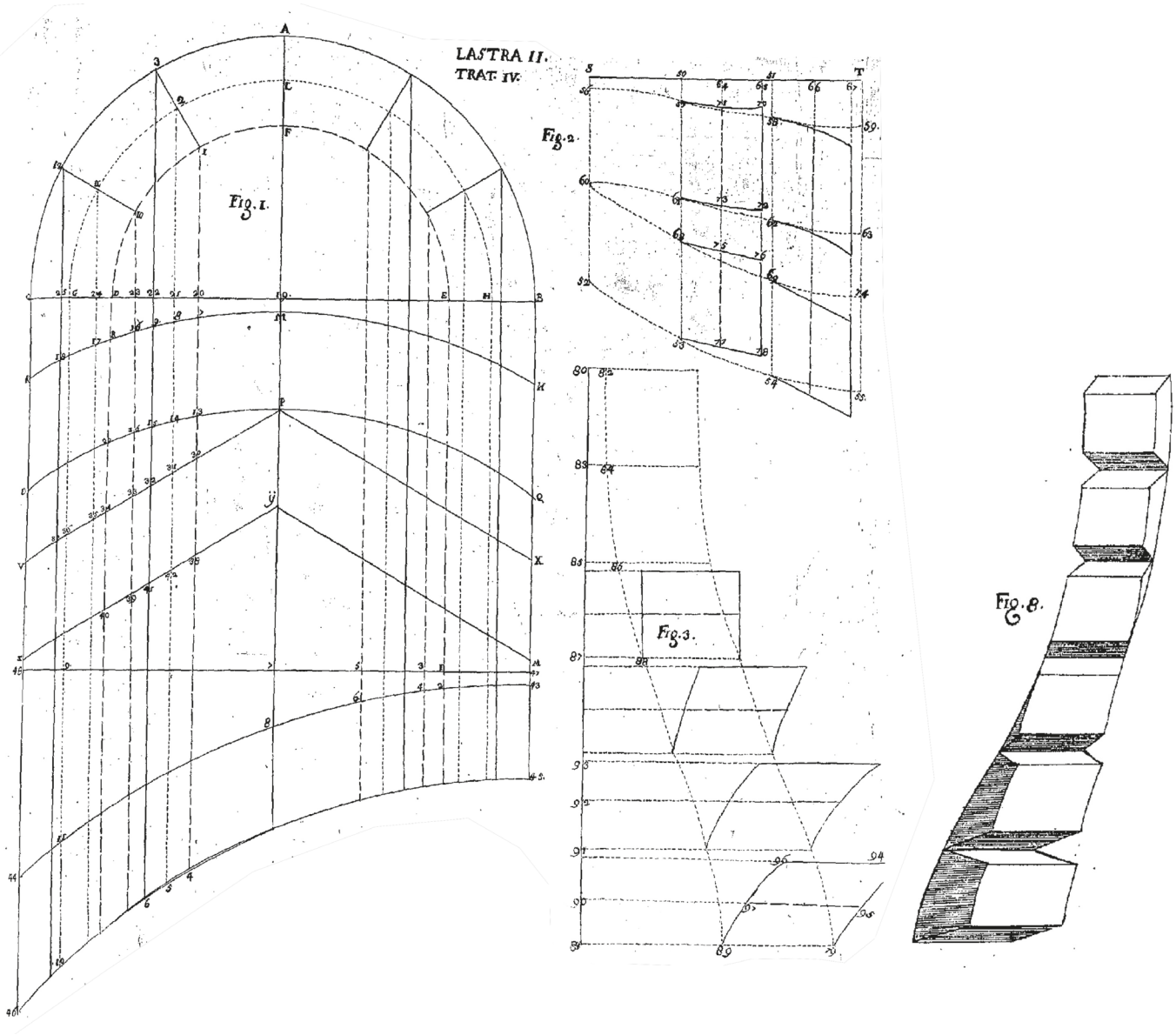
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Fig. 1.
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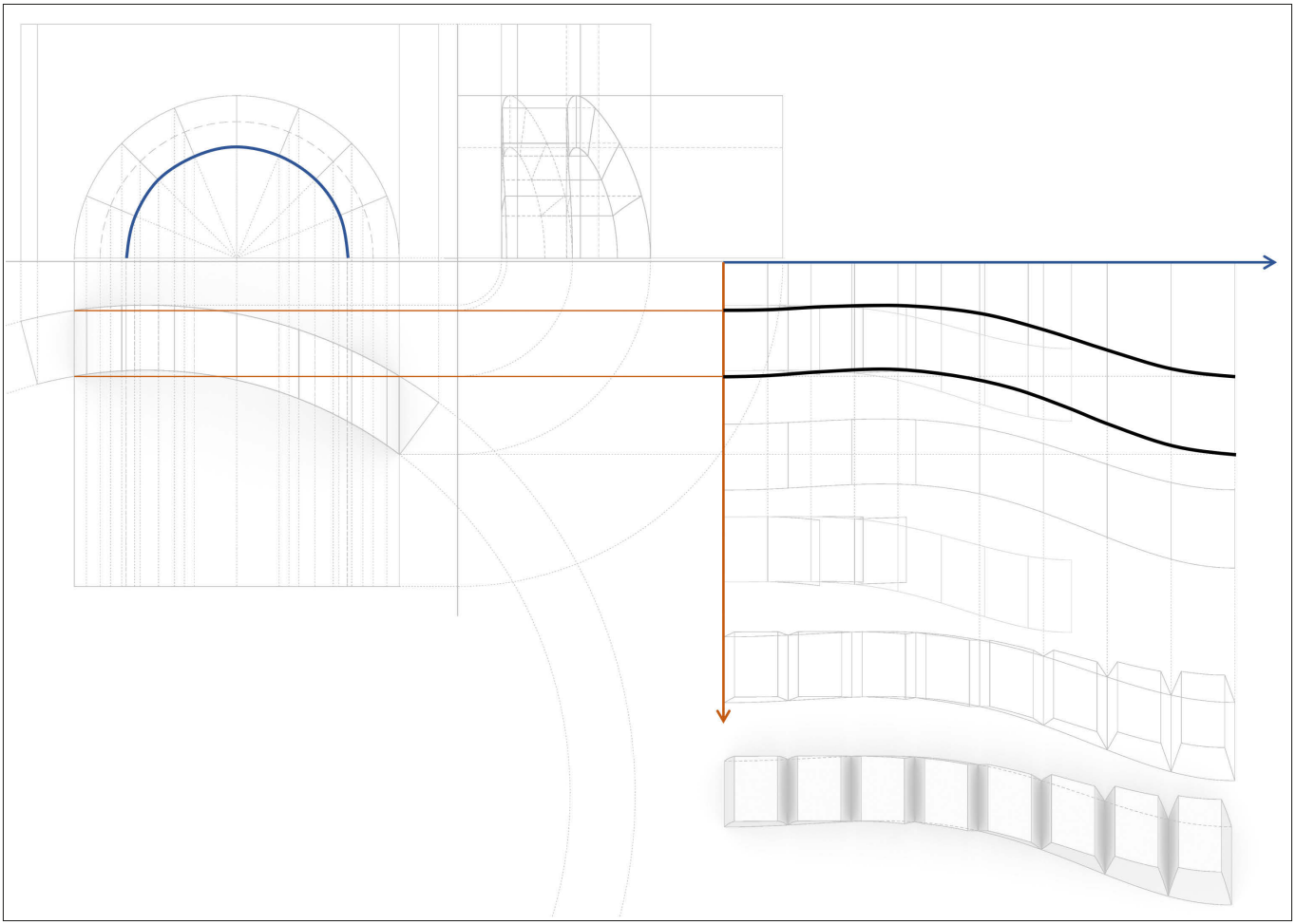
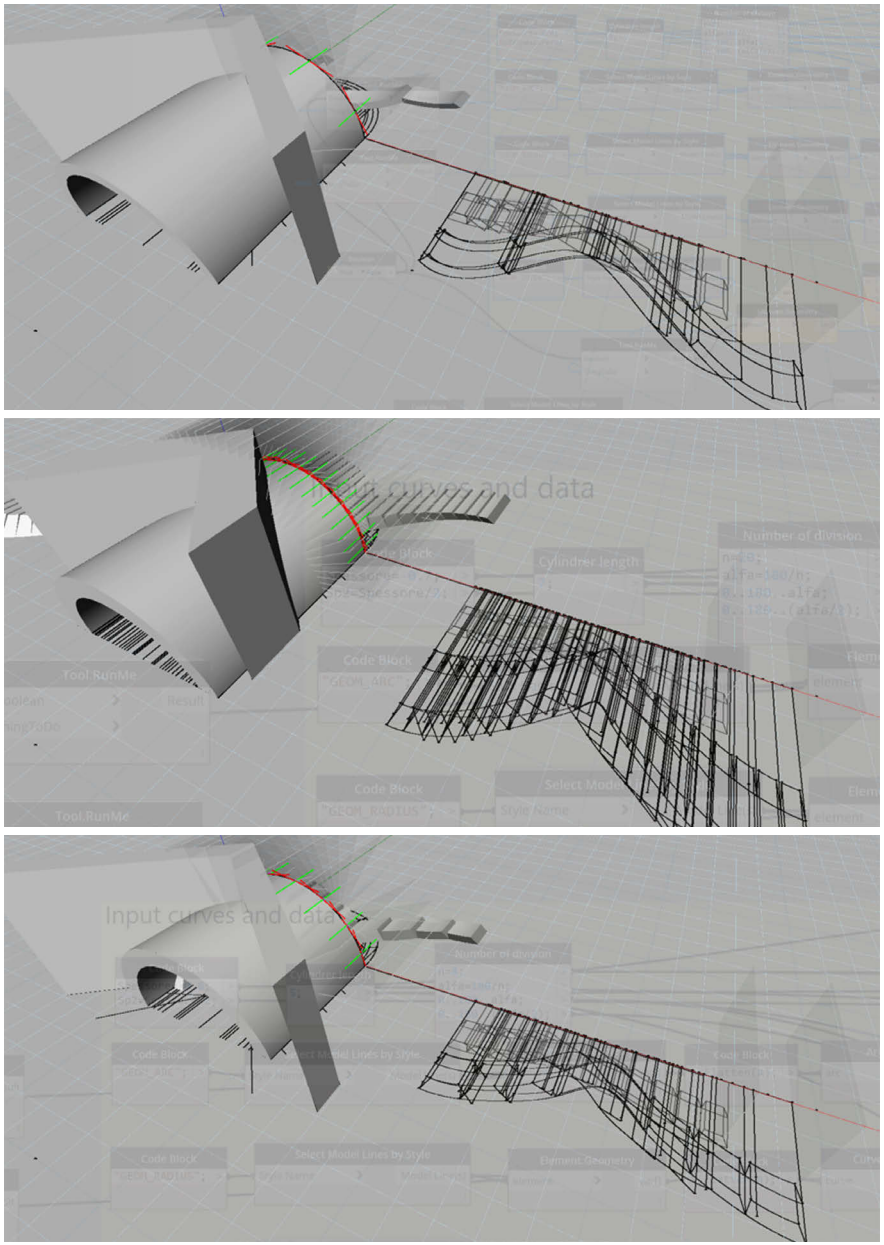
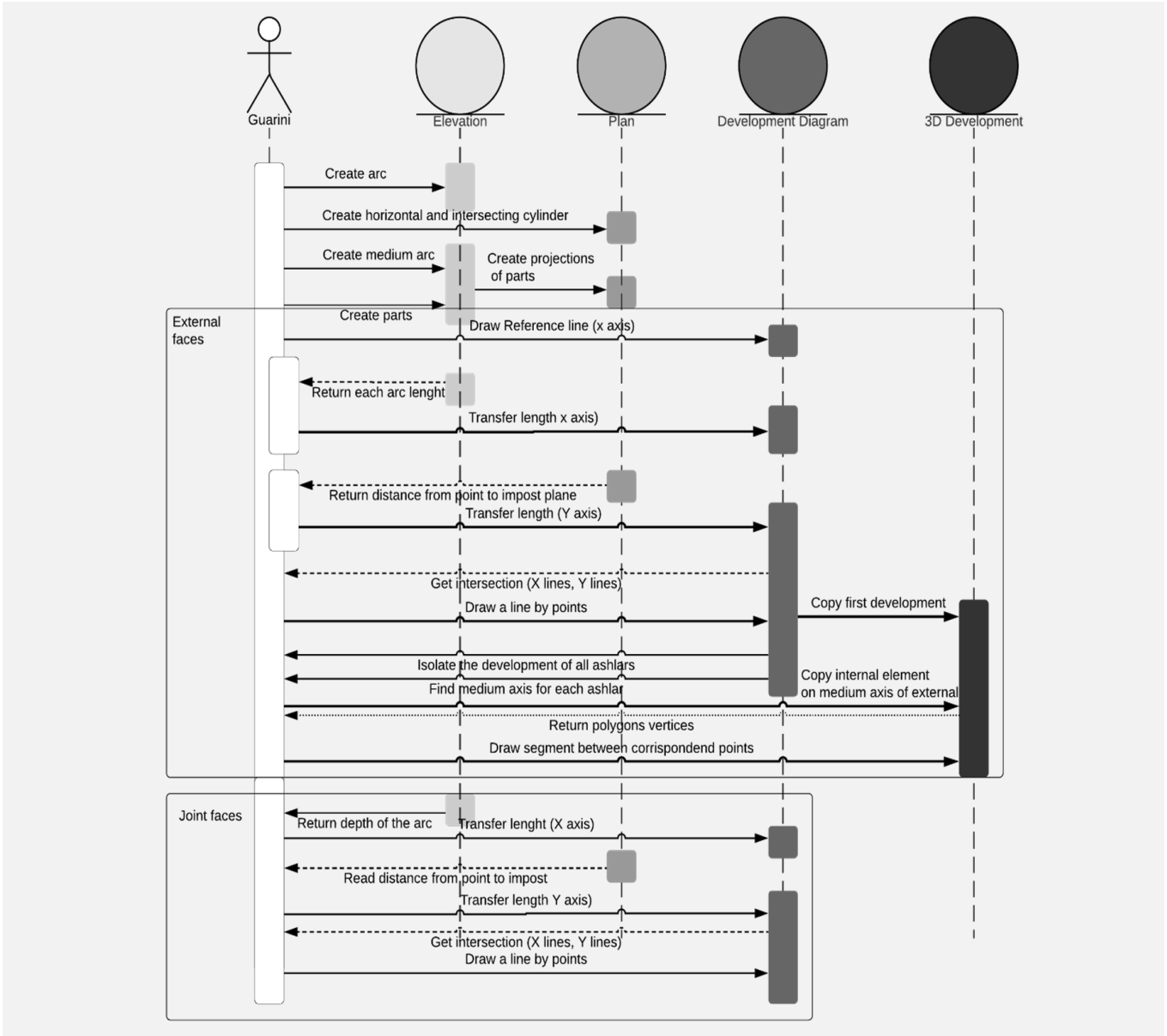


Fig. 4 – Monge representation and production of the Guarini two-axis graph to obtain the development of the intrados surface.

Fig. 5 – Different solutions for the cylinder intersected by a projecting plane produced from the script.


Input curves and data
Input curves and data


Guarini
Elevation
Plan
Development Diagram
3D Development
Create arc
Create horizontal and intersecting cylinder
Create medium arc
Create projections of parts
Create parts
External faces
Draw Reference line (x axis)
Return each arc lenght
Transfer length x axis)
Return distance from point to impost plane
Transfer length (Y axis)
Get intersection (X lines, Y lines)
Draw a line by points
Copy first development
Isolate the development of all ashlars
Find medium axis for each ashlar
Copy internal element on medium axis of external
Return polygons vertices
Draw segment between corrispondend points
Joint faces
Return depth of the arc
Transfer lenght (X axis)
Read distance from point to impost
Transfer length Y axis)
Get intersection (X lines, Y lines)
Draw a line by points

of *Architettura Civile* [3] about the projections of cylindrical surfaces [Guarini 1737]. Guarini presented 15 different stereotomic cases, which are solved with two different scripts, as the surfaces intersecting the initial cylindrical surface change. The first three cases concern the intersection of the cylindrical surface with vertical cylinders or projecting planes, as shown in figure 1.
Guarini proposes a graphical method, in which he transfers the measurements taken on the planar and vertical projection (fig. 3) into a two-axis-based graph (fig. 4). On the blue axis, Guarini marks the lengths of the development of the internal arc, while on the red axis, he reports the length along the generatrixes, taken from the horizontal projection. The procedure gets a point for each correspondent axis. The case ends by conducting a curve through these points. The mechanical procedure of transferring distances and angles belonging to horizontal, vertical, or overturning planes, can be easily translated into sets of geometric rules composing the script. For example, the script traces a NURBS curve (in black) by geometric interpolation of the intersecting points (black line in figure 4). This result seems to confirm a historical continuity between manual operation involving naval architecture and built surfaces [Nowacki, Lefèvre 2009].
The script works on all types of surfaces, in this sense the approach here presented is completely parametric (fig. 5). Moreover, once a procedure has been scripted and the outputs are geometrically verified, the script itself can then be expanded to other forms of other exercises and other stereotomic cases, so the starting surfaces could be represented, for example, by a cylinder cut on one side by an oblique plane and the other by a cylindrical surface.

6 - The UML sequence diagram illustrates geometric operation in Guarini's stereotomic cases.

However, the first aim of using scripting in Guarini's work was to effectively compare the treatises. UML sequence diagram enables to outline the operations of the script within a new graphic universal language, allowing to standardize the operations described in the treatise, making them dependent neither from the author nor the software and programming language used (fig. 6). Thanks to the UML diagram, the logical path of Guarini's procedures is understandable and comparable with others authors.
The procedure here described demonstrated how the procedures explained by Guarini are still distant from the later theory by Gaspard Monge. Some cases, for instance, are entirely taken from *L'Architecture des voûtes, ou l'Art des traits et coupe des voûtes*, the treatise by François Derand (1588-1644) the treatise by François Derand, showing how Guarini's models were at that time well-established. However, this does not exclude Guarini from being part of the improvement of geometric constructions.

Notes

1. The Ortografia is an impression, termination, print, annotated on a plan of a surface normal to it. The surface surrounds another surface raised up from the first plane; from this print, orthogonally impressed, it is known the magnitude covered and occupied by the plane itself.

2. Visual Programming "refers to any system that allows the user to specify a program in a two (or more) dimensional fashion. Conventional textual languages are not considered since [...] it as a long, one-dimensional stream." [Myers 1986, p. 63**].** Examining software that have been developed over this environment, they were born around the 80s. Two references seem to be important: Houdini – formerly Prims – with its module *Ice*, and *ConMan* by Paul Haeberli [Haeberli 1988] (fig. 3).

3. Guarini 1737, *Trattato Quarto, Dell'Ortografia Gettata*. Capo 3, *Della proiezione delle superfici cilindriche*, pp. 196-222.

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Francesca Gasperuzzo (Treviso 1981) graduated in Architecture at the Iuav University of Venice with a thesis on a particular form of art and architecture, the perspective boxes painted in distorted perspective (anamorphic) in the Dutch in the 17th century. Since that moment he has been interested in the history of representation and its relationship with contemporary art, collaborating with the *Imago Rerum* team (Iuav) coordinated by prof. Agostino De Rosa. She was fellow at the University of Engineering in Padua with a project about two architectural perspectives painted by Mantegna in Padua (Cappella Ovetari). Currently she is Ph.D. (Iuav) with a thesis on the oblique architecture of the cistercian monk Juan Caramuel de Lobkowitz and the architectural treatise *Architectura civil recta y obliqua* (Vigevano 1678).

09 CARAMUEL, AN ARCHITECT IN VIGEVAN AND THE RULES OF HIS OBLIQUE PROJECTED GEOMETRY

Francesca Gasperuzzo

Abstract

This article outlines the critical methodology of Spanish theologian Juan Caramuel de Lobkowitz for the design of his only surviving architectural work: the 'oblique' façade of Vigevano Cathedral, a unique structure amongst religious buildings.

Critics thought it bizarre; the work of a theologian with an interest in architecture but one without experience in the profession. Yet the façade has never before been the subject of a dedicated geometrical study. As such, this article provides fresh insight into the reasoning behind a truly eclectic design.

The research presented in this article is based upon a laser-scanned survey of the concave façade. This was analysed digitally to shed new light on the geometrical design, as theorized by Caramuel in his architectural treatise *Architectura civil recta y obliqua* (Vigevano 1678).

Il presente contributo intende presentare l'approccio critico e metodologico adottato sull'unica opera del teologo spagnolo Juan Caramuel de Lobkowitz giunta ai giorni nostri: il progetto (obliquo) per la facciata del Duomo di Vigevano, un unicum per quanto concerne la progettazione di un edificio sacro. L'intervento fu considerato dalla critica il bizzarro esito progettuale di un teologo interessato all'architettura ma estraneo alla pratica professionale, e la facciata vigevanese non è mai stata oggetto di uno studio puntuale rivolto a mettere in luce le possibili ragioni geometrico-progettuali che portarono il Vescovo a un progetto ritenuto così controcorrente. L'operazione si è avvalsa di un rilievo strumentale del manufatto architettonico e del ricorso al disegno digitale, utile strumento di verifica del "sistema progettuale obliquo" teorizzato dal Vescovo nel trattato di architettura di riferimento *Architectura civil recta y obliqua* (Vigevano 1678).

The cistercian monk Juan Caramuel de Lobkowitz (Madrid 1606-Vigevano 1682) was in many ways a product of the baroque scientific culture of his day. An insatiable theologian-mathematician-polygraph, engaged within the most active intellectual and scientific circles of the time, he took an interest in architecture as a young man.[1] From then he began working on his *Architectura civil recta y obliqua* (Vigevano, 1678),[2] an imposing treatise on architecture, written in Spanish but printed in Vigevano in 1678 during his service as a bishop (fig.1); this publication coincided with the commission of works that would lead him to address the *ars aedificandi* for the first time (fig. 2).

Towards the end of 1673, the historic centre of Vigevano featured two disruptive elements: the striking misalignment of the Cathedral with the length of Piazza Ducale, and the interruption of the southern line of *portico* framing the piazza by a large stairway, which corresponded with the tower designed by Donato Bramante and provided access to the courtyard of the Sforza Castle seven metres above ground level (fig. 3).

Caramuel proposed an innovative project: a surprising new element to consolidate the cathedral-stairway-tower system in the form of a new façade for the cathedral. The new addition has a concave form and stands perpendicular to the axis of the piazza; it acts as a stage curtain for the piazza, establishing a new spatial and visual boundary. Caramuel's renovation was completed by the replacement of the original large stairway with a single flight of stairs, positioned behind the *portico* in correspondence to the tower, and the continuation of the existing *portico* (fig. 4).[3]

The cathedral project has a unique feature: an even number of openings only the two central of which lead to the interior, while the lateral portals provide access to an octagonal courtyard (now the baptistry) on the right, and directly to the street along the north side of the cathedral (now Via Roma) on the left. This is one of the most striking and innovative features of the project. A second

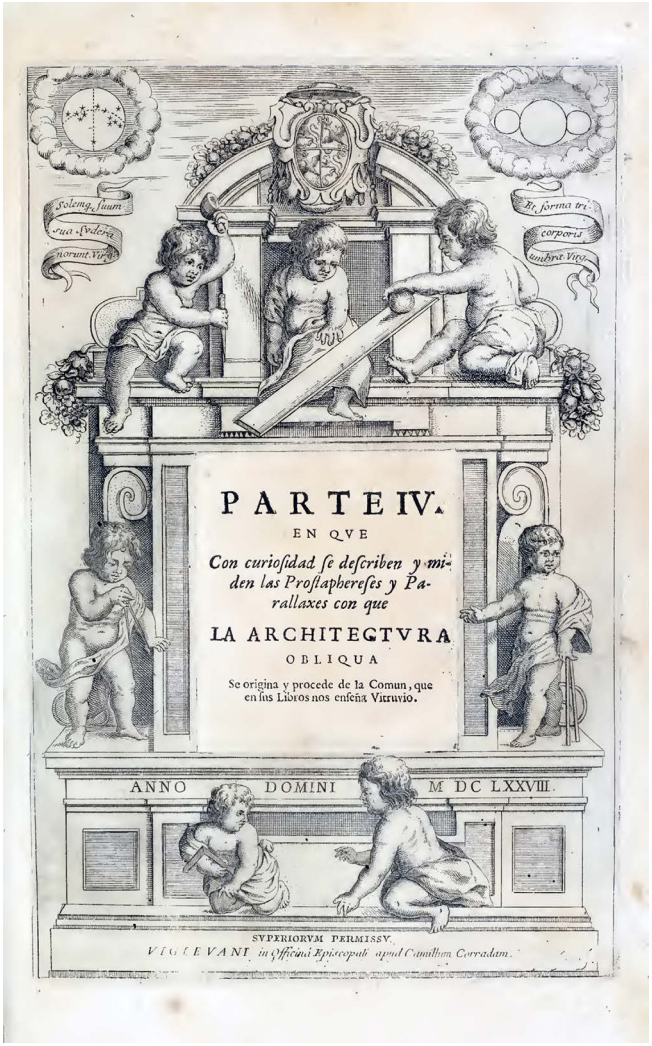
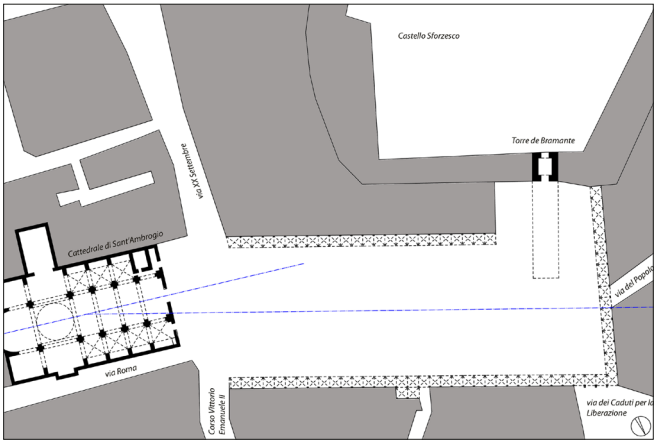


Fig. 1 - Caramuel de Lobkowitz, J., Architectura civil recta y obliqua, Book III, Vigevano 1678.

Fig. 2 - Façade of the Sant'Ambrogio Cathedral, Vigevano, 2021 (photograohy by F. Gasperuzzo).



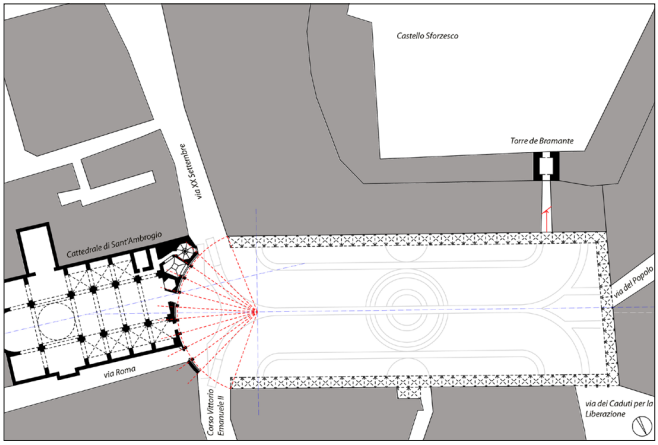


Fig. 3 - Historic center of Vigevano before Caramuel's project.

Fig. 4 - Historic center of Vigevano post Caramuel's project.

Fig. 5 - The oblique façade and the connection with the medieval cathedral.

noteworthy element occurs at the upper level, where the opening on the right functions as a window, while the left-hand opening sits against the pre-existing wall of the cathedral; this blind window has the only function of making the façade symmetrical (fig. 5).

Research conducted at the Fondo Caramuel, an archive where all documents relating to the literary and professional output of the bishop are kept, confirmed the direct involvement of Caramuel in the construction of the façade. Yet the process confirmed the absence of any drawings relating to the project. It was therefore necessary to focus this research on existing primary sources: examination of Caramuel's architectural treatise on *architettura obliqua* in which his *modus operandi* is described, with particular reference to *Book VI* which is dedicated entirely to oblique architecture – alongside digital analysis of the current structure.[4]

The treatise was intended for an audience of cultured architects and patrons of major building works, who were provided with a code of universally applicable principles relating to '*architectura obliqua*'. The author establishes precise rules for the projected geometry, supported by 162 didactic illustrations,[5] in order to set out an architecture of almost divine perfection.[6] The theoretical-geometric system devised by Caramuel is based on an extremely rigid methodology; the rules for oblique projected geometry are applied using a rigid mathematical formula. The oblique geometry is divided into three categories depending on whether it is projected horizontally ('*declinación*' and '*circulación*'), vertically ('*inclinación*') or both ('*circulación + inclinación*').[7] Even when an architectural surface is not regular, Caramuel states that the rules set out in the treatise must still be followed, even at the expense of deforming architectural elements to the limit of what can be built in practice.

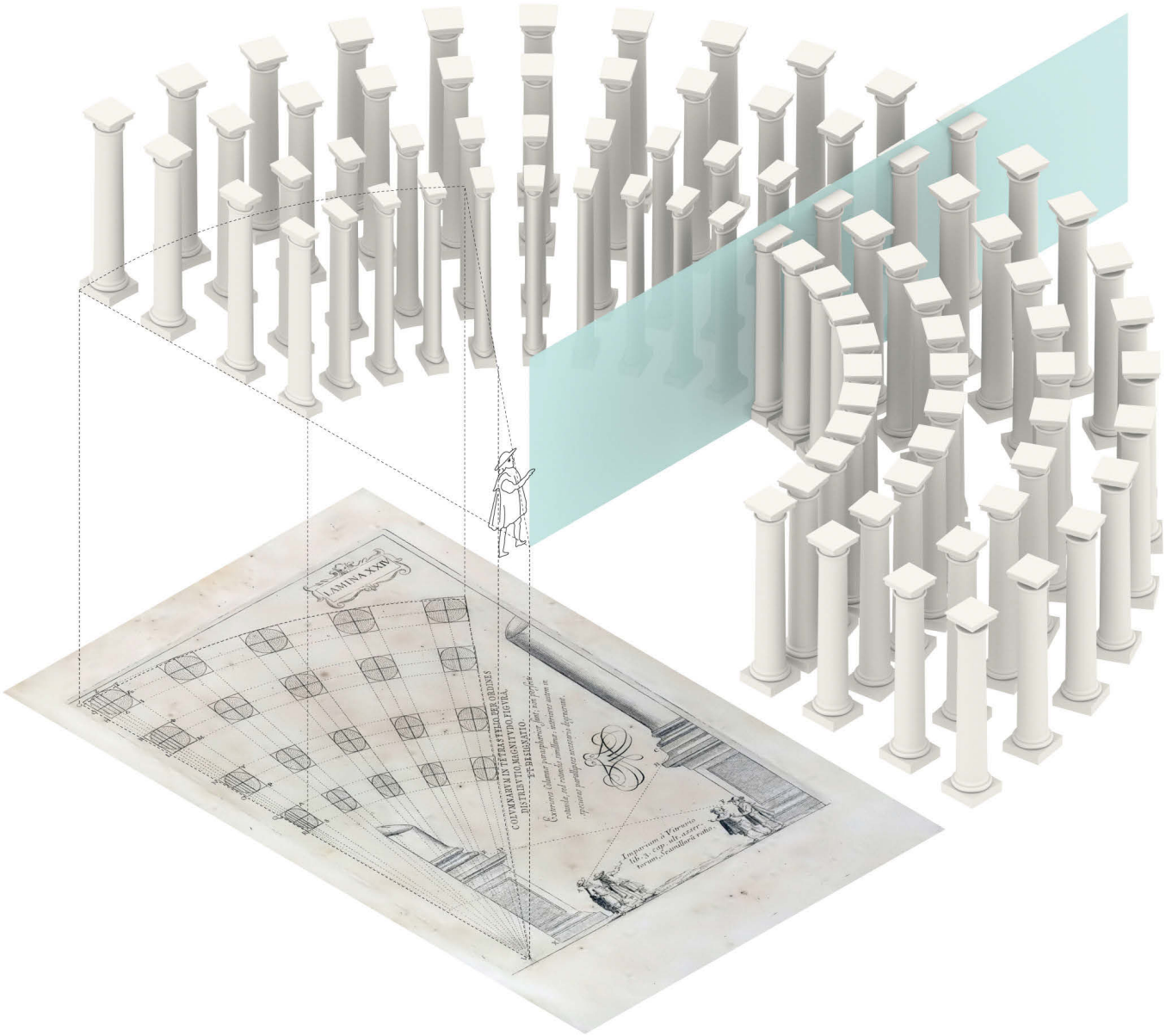
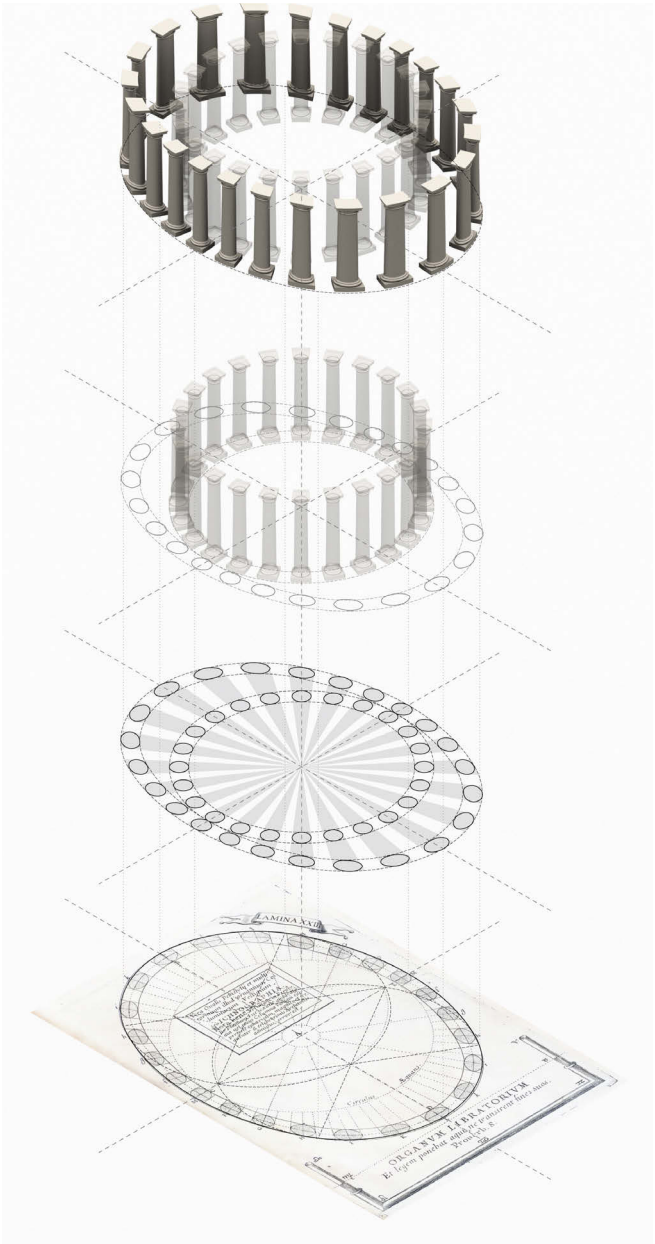
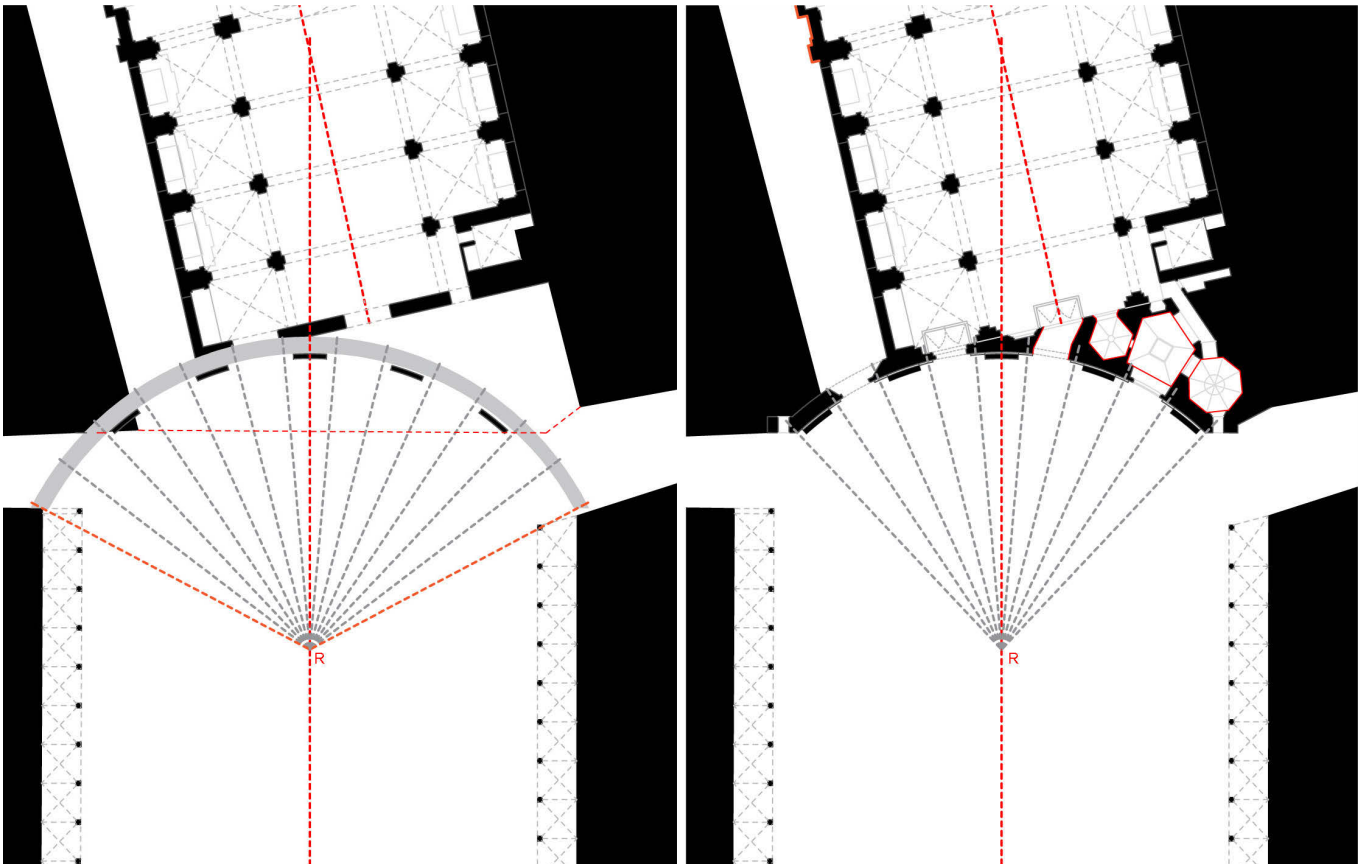


Fig. 6 - Caramuel de Lobkowitz, J., Architectura civil..., Book III, Lamina XXIV (digital elaboration by F. Gasperuzzo).

Fig. 7 - Caramuel de Lobkowitz, J., Architectura civil..., Book III, Lamina XXIII (digital elaboration by F. Gasperuzzo).

The interpolation of the metric and volumetric data of the entire Vigevano piazza, recently acquired by laser scanner, has allowed us to confirm that the façade stands along the arc of a circle.[8] The first category of Caramuel's system is therefore the most relevant, in particular the *circulaciòn* represented in *Lamina* XXIII and XXIV of *Book III*. In the first of these drawings, Caramuel illustrates the plan of an elliptical peristyle composed of twenty-four columns arranged in a single row, in the second the development of a circular tetrastyle colonnade. As clearly shown in *Lámina* XXIV, the section of columns arranged along the divided circumference (*circulus aequans*) undergoes the same radial deformations along the perimeter (divided into regular intervals of 9°). These will be *circuli imperfecti*, with a trapezoidal base and capital, and two arcs of concentric circles and two straight segments will run through the relative planimetric centre of curvature. They will also undergo deformations directly proportional to their distance from the centre: those belonging to the external circumference, further from the privileged point of origin (indicated in the plan by the letter 'V') will be subject to a minimal, almost imperceptible *obliquación* (oblique deformation), while those nearest, vice-versa, will be subjected to the maximum *obliquación* (fig. 6). The question arises again in *Lámina* XXIII where a hypothetical circular colonnade, with centre *A* and diameter equal to the minor axis of a circumscribed ellipse is divided radially into 24 segments, following a constant alternating of angles of 9° and 6° that correspond respectively to the section of the columns and intercolumns. The columns are rendered oblique along the *circulus aequans* in accordance with the principles described in the treatise. When projected onto the external ellipse, their form adheres to Euclidian principles (where different objects take on the same apparent dimensions if placed in the same angle of vision) and undergoes planimetric distortion that is more evident in relation to the major axis, and less evident in relation to the minor axis, where the columns almost retain a circular form (fig. 7).





In light of these considerations, it is worth pointing out that Caramuel's façade, configured on a *circulus aequans* with a radius of 27 metres, perfectly centred in relation to the transversal axis of the piazza (point *R*) and a tangent of the lateral walls of the *portico*, can be read as an alternation between full and empty parts which correspond to the consistent division of the arc of a circle in segments of 9° (with entrance portals corresponding to 6° segments). Caramuel also appears to follow the plan from *Lámina* XXIII in choosing to place a solid wall at the centre of the façade (a particularly unusual choice for a religious building), instead of the opening we would expect to find in correspondence with the central nave. In fact, the new façade is positioned only tangentially to the pre-existing building, and the hinge that holds the old and the new structures together is positioned where the paired half-pilasters mark the central axis of the façade. The rest of the façade follows a concave curvilinear path independent of the pre-existing building, as can be clearly seen when viewing

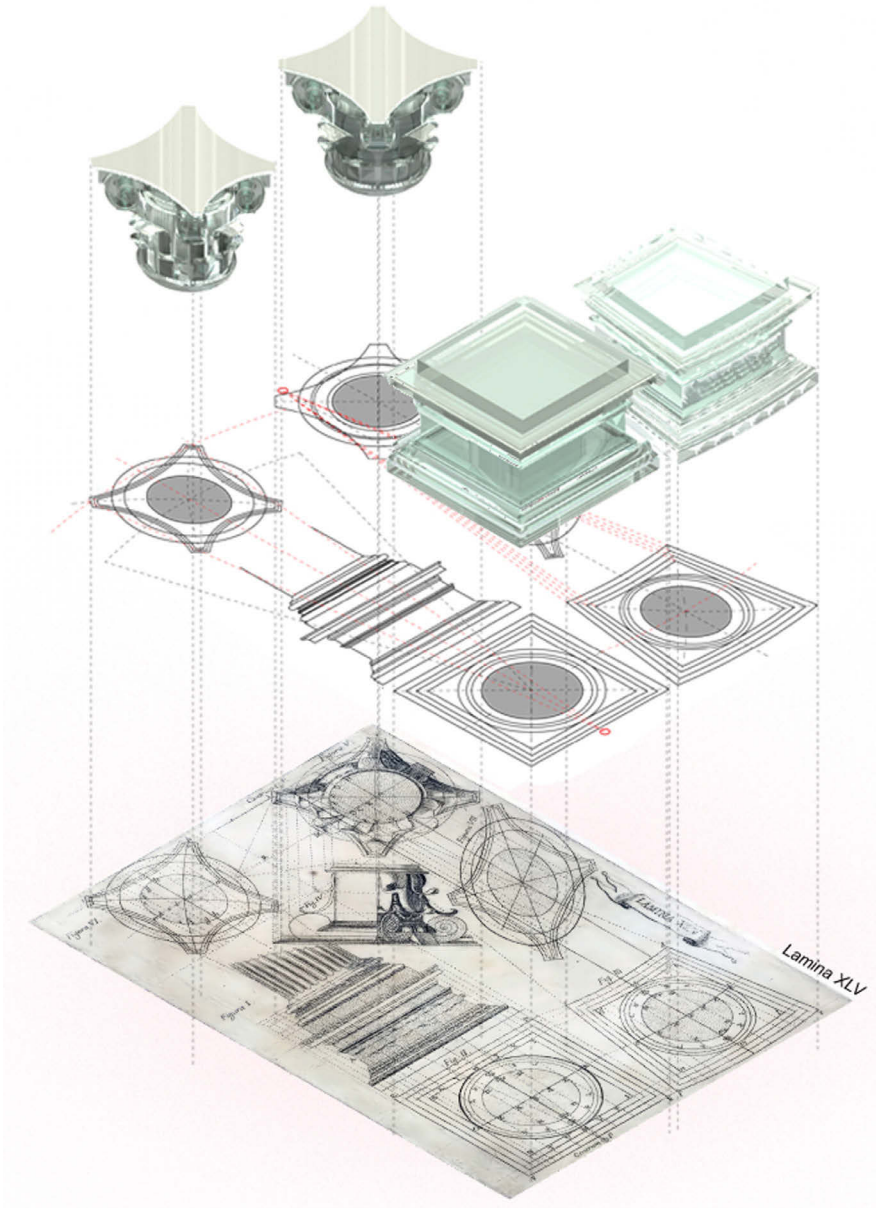
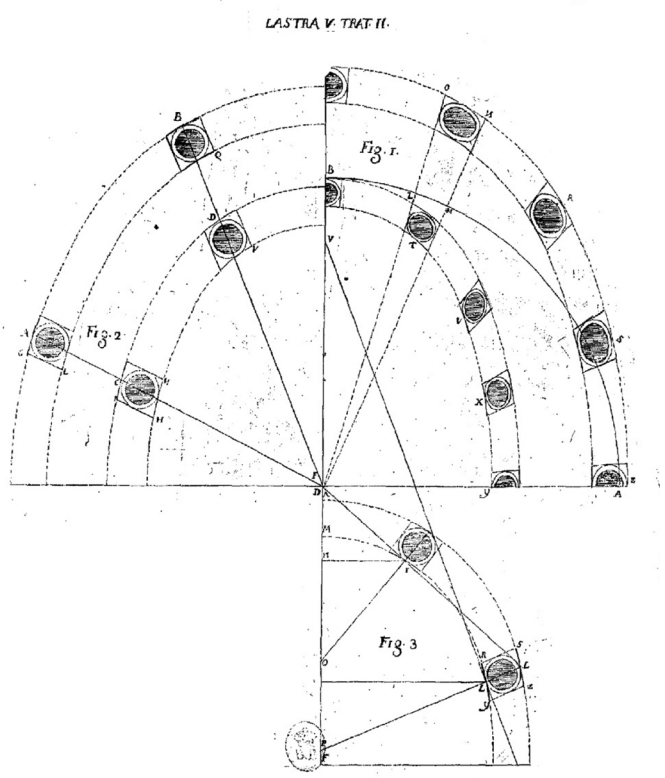


Fig. 8 - Comparison between Caramuel scheme of circulación and the plan of Vigevano project.

Fig. 9 - Caramuel de Lobkowitz, J., Architectura civil..., Book III, Lamina XLV. (Digital elaboration by F. Gasperuzzo).



the cathedral from the side. Digital drawings also confirm the extent to which the projected geometry complies with the laws of the *circulación*: the radial walls have the same centre *R*. This relates to the distribution of the areas delineated in the residual space between the rectilinear wall of the medieval cathedral and the baroque concave structure (a hexagonal chapel, the pentagonal baptistery accessible from the right portal and the octagonal ossuary located in correspondence to right-side wing) (fig.8).

Thus, the planform of Caramuel's façade appears to have followed the theoretical rules of *Architectura civil recta y obliqua*, yet the building was forced to deviate from them during construction, when Caramuel was confronted by the practical realities. For example, in order to meet the geometric-projective criteria of *Lámina* XXIV, the bases of the columns, given their distance from the centre *R*, should have a minimum deformation equal to a rotation angle of 1°. Creating a column with an oblique deformation of this kind, in the order of millimetres, would have been a major challenge even for the most highly skilled stonecutters (fig. 9).

This discrepancy between theory and practice seems to have been a common occurrence in the architectural designs of major baroque buildings in Rome. Rocco Sinisgalli suggests, for example, that when designing the gallery of Palazzo Spada (1652-1653), Francesco Borromini (1599-1667) found a fourth dimension to guide the design (the way visitors move around the gallery) to make columns with very similar sections for the entire length and breadth of the space, rather than following the principle of a gradual narrowing in relation to a single privileged viewpoint to define the optical illusion.[9]

A few years later, when designing the Church of Sant'Andrea al Quirinalef, described by Caramuel as an example of "masterful architecture"[10], Gian Lorenzo Bernini (1598-1680) set each of the two columns of the semi-circular porch on a trapezoid base made up of two arcs of concentric circles and two convergent rectilinear segments, but with the column itself having a circular section. In this case, the curved radius dictated by the narrow porch would have required, in Caramuel's oblique system, a substantially stretched elliptical section, given the proximity to the centre of curvature. Guarino Guarini did not miss the opportunity to openly criticize Caramuel's oblique column, describing it as "an object that will lead to the complaint that it is too wide on one side and too narrow on the other"; affirming that "a building's context should never interfere with the building's proportions".[11]

We have clear evidence of this in Plate V of *Architettura civile* (1737), in which Guarini compares Caramuel's oblique solution with his own: the latter being better

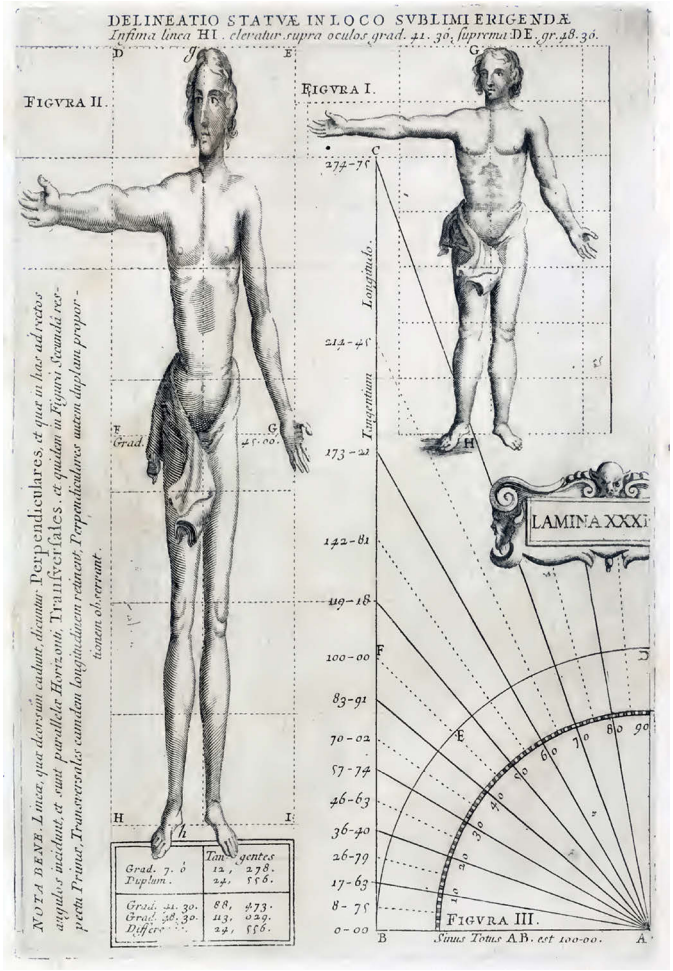


Fig. 10 - Guarino Guarini, Architettura civile, Lastra V, Book III, De modo di disporre un colonnato nel tondo. Fifura I: Caramuel's oblique solution; Figurs II, III: Guarini's solutions.

Fig. 11 - Caramuel de Lobkowitz, Architectura civil..., Book III, Lámina XXXI.

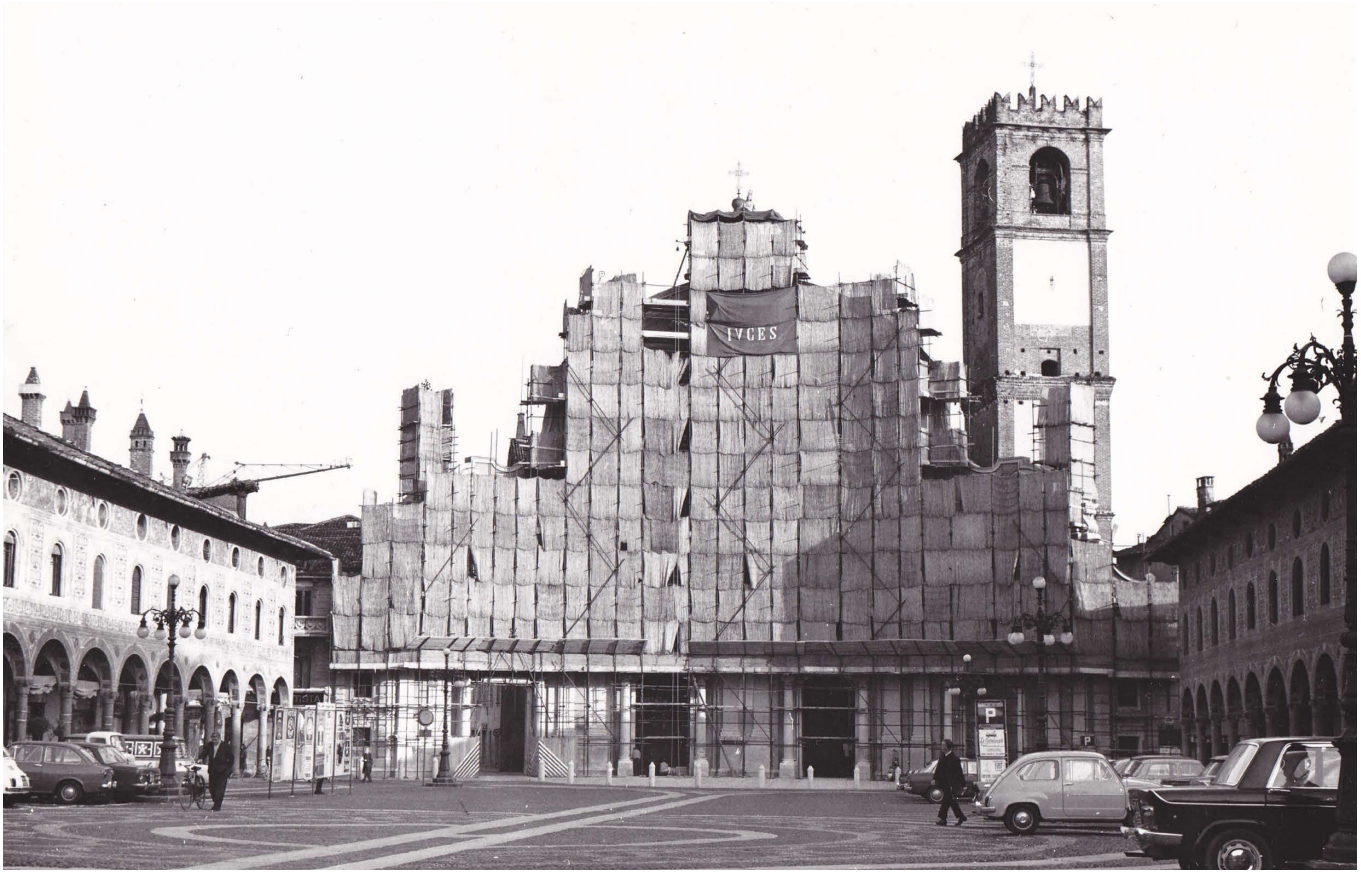
suited to address the practical problems of the building site (fig. 10).

A natural continuation of this study would involve applying the same methodology to the vertical development of the façade, so that its adherence to Caramuel's rules for vertical *obliquación* (*inclinación*) can be tested and verified. These rules are laid out in *Book VII*, which is entirely dedicated to oblique projected geometry.

Caramuel suggests transforming, or rather lengthening, by means of a linear deformation that follows a geometric grid like that proposed in the treatises of Egnazio Danti (1536-1586) or Samuel Marolois (1572-1627), architectural elements such as statues, capitals with volutes, inscriptions, or clocks, so that they appear to be undistorted by perspective when seen from the ideal vantage point on the ground (fig. 11). In the case of Caramuel's façade, this is extremely difficult to verify because the upper level, as it is today, is markedly different from the original: the façade has been altered during numerous restorations. The most substantial modification to the upper level occurred in the early 20th century, during the restoration directed by the architect Gaetano Moretti (1860-1938). Inspired by the desire to harmonize the lower and upper levels, he extended the cornices of the second order openings to meet the entablature of the first, adding a concrete balustrade. To make the façade more dynamic, Moretti also modified the connecting volutes of the side wings, as well as the San Carlo and Sant'Ambrogio statue pedestals at the top, replacing the lateral statues with the current obelisks.

Research carried out during the 1965 restoration, under the guidance of the architect Mario Bonzanini (1923-2010), uncovered some interesting features. From the tests carried out on the capitals on the second level, it seems as though these originally supported the base of the curved pediment, but it is not clear whether the modification of the proportions of the upper level took place during or shortly before Moretti's intervention. In either case, the addition

Fig. 12- Facade of the Sant'Ambrogio Cathedral, Vigevano, 1965 (photography by F. Gasperuzzo).



of a frieze involved substantial modification of the upper orders, and the flattening and shortening of the openings compared to the original composition.[12] The large cartouche with a dedication to Saint Ambrose, positioned in the centre of the curvilinear front, was added during the eighteenth century. In Caramuel's design, the central pair of half-pilasters, marking the axis of symmetry of the façade and the vanishing point of the geometric lines of Piazza Ducale, continued to the top of the façade which, in full Baroque spirit, became the backdrop for the piazza (fig. 12).

Notes

1. Caramuel 1678, *Book II, Treatise VI, En que se ensena la Architectura obliqua*, p. 2.

2. The complete title is *Architectura civil recta y obliqua, considerada y dibuxada en el Templo de Jerusalem, promovida a suma perfeccion en el templo y palacio de S. Lorenço cerca del Escurial que inventó el rey D. Philippe II*. A partial reprint of the treatise and the illustrations is included in the text edited by the Società Storica Vigevanese entitled *Por Don Ivan Caramuel, De l'architectura civil recta y obliqua.* Vigevano: Diakronia 1997.

3. Giordano 2006, pp. 129-143.

4. The survey was carried out in 2019 in collaboration with Alessio Bortot and Cristian Boscaro. Given the small size of the artefact (the façade is 38 metres wide and 25 high), about 30 scans were required; this was followed by a manual input with *ReCAp 360 Pro*. Finally, the point cloud was imported into *Rhinoceros* to build the digital model.

5. Caramuel 1678, *Book II, treatise VI, Article VIII, Como han de ser estas mismas Bases y Colunas, si el Peristylio huviere de tener tres naves, y de quatro en quatro las Colunas?*, p. 12.

6. Caramuel 1678, *Book I, Treatise I, En que se proponen y explican con brevedad y claridad, todas las Facultades Literarias, que ha de saber, y exercitar un Architecto*, p.4.

7. Caramuel 1678, *Book II, Treatise VI, note in Article III, De las especies de la Obliquidad*, p. 5.

8. The outcome diverges from the one carried out in 1983 by the Istituto di Restauro della Facoltà di Architettura di Venezia that proposed an arc of an ellipse, a part of which was published in Brusatin 1986, pp. 141-166.

9. Sinisgalli 1998.

10. Caramuel 1678, *Book II, treatise IX, Article IV, De las Laminas, que pertenecen a la Architectura Obliqua*, p.108.

11. Guarini 1737, p. 10.

12. For more information about the restoration works, see <https://archiviobonzanini.wordpress.com> (last accessed April 18, 2021), *Introduction*.

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11 METHODS AND INSTRUMENTS FOR OBSERVATION, DATA ACQUISITION AND MULTIDIMENSIONAL ANALYSIS: THE PASSING OF TIME IN THE DOCUMENTATION OF CULTURAL HERITAGE

Francesca Porfiri

Abstract

The intervention focuses on the process of normalisation and integration of a system of data (gathered over a period of time and part of a much broader research project) regarding the Arch of Titus in Rome, in particular an accurate qualitative acquisition system and its comparison with quantitative-mass data. The objective of the research and this contribution – an integral part of the research – is to create a multiple, integrated, descriptive model. The assessment and synchronic and diachronic comparison, based on the time variable, was performed using a topographical survey, i.e., an accurate element of 'comparison and reassurance' with previous surveys. Data systemisation allows for transversal critical interpretation of a case study that has undergone important changes over the years; the interpretation highlights the importance of scientifically verifying accrued data, given the huge mass of data acquired so far in the field of architectural survey.

L'intervento proposto è incentrato sul processo di normalizzazione e integrazione di un sistema di dati, raccolti nel tempo all'interno di un ampio progetto di ricerca, riguardante l'Arco di Tito a Roma; si focalizza in particolare sul sistema di acquisizione a livello qualitativo e puntuale e del confronto di esso con il dato quantitativo-massivo. L'obiettivo di tale ricerca e di questo contributo, che si inserisce al suo interno, è quello di creare un unico modello descrittivo, multiplo e integrato. La valutazione e il confronto sincronico e diacronico, declinato secondo la variabile temporale, viene eseguito in particolare attraverso il rilievo topografico, elemento puntuale di "confronto e conforto" con i rilievi precedenti. Mettendo a sistema i dati raccolti si propone una lettura critica trasversale, applicata ad un caso studio testimone di importanti cambiamenti nel corso del tempo, capace di mettere in luce ad oggi l'importanza della verifica scientifica del dato, a fronte di un'ingente acquisizione di esso nel campo del rilievo architettonico.

Introduction

A complex architectural object that has undergone important changes over the years needs to be studied, understood and then illustrated in all its parts so as to highlight and substantiate its tangible and intangible memory. With the passing of time an architectural work evolves seamlessly; it undergoes important changes or imperceptible alterations to its morphology and material essence and is defined not only by its spatial coordinates or intrinsic materials, but also by the way it changes over the years, something that makes it unique and completes its narration. As a result, two different interpretations are required: one synchronic, the other diachronic. The first deals with a reality linked to the knowledge available at a specific moment in time, a reality in which all aspects are considered as a system governed by precise laws regarding function; instead, the latter considers the evolution of all the phenomena studied as an ensemble in order to identify precise laws regarding change. Based on these two interpretations, the objective of any study is to transfer knowledge of the object in question to future generations by providing accurate documentation, interpretation and management of the data acquired thanks to an integrated approach. In this case, the joint participation of several players – architects, archaeologists, historians and restorers – plays a key role. In the last fifty years digital instruments have become commonplace in the analysis and acquisition of cultural heritage, especially in the field of architectural survey and communication of its findings. Although this is common knowledge within the scientific community, it is also possible to provide further experimental input by applying this

Fig. 1 - The Arch of Titus, located in the Archaeological Park of the Colosseum.

Fig. 2 - Three historical representations of the main phases of the Arch of Titus: left, Giovanni Battista Piranesi, historical view of 1755-1765; middle, Gaspare Vanvitelli,18th century view; right, the view after restoration of Luigi Rossini in 1836.

knowledge to a specific case study. This will involve weaving a sort of invisible web in order to create patterns that can scientifically and ontologically re-connect the elements of the work in question. After all, its true essence can only be identified by monitoring existing geometries and thus revive lost geometries – a task achieved through accurate data acquisition.

An Integrated Knowledge-gathering Model for the Arch of Titus

Three main temporal phases characterise the old monument down through the centuries:
- its construction in 81 A.D. by Emperor Domitian to celebrate the heroic acts of Emperor Titus;
- its incorporation into the fortifications of the Frangipani in the Middle Ages; although the arch lost part of its unitary identity, it also led to its partial conservation;
- finally, its anastylostic restoration by Stern and later Valadier between 1817 and 1824.[3]

The monument was in a dreadful state prior to restoration [Jonsson 1986, pp. 99-117]; although several elements of its old structure were missing, the barrel vault was still in place, as were the bas-reliefs, the half-columns and entablature, parts of the frieze, and the commemorative epigraph on the attic. The vaulted room inside the attic has been there since antiquity, probably to reduce the weight of the arch. When Valadier restored the monument, he deliberately chose to simplify the architectural order as regards the decorative motifs and use of materials, for example by replacing marble with travertine (fig. 2). The current quadrilateral morphology of the free-standing monument includes a base, a monumental attic, a central arch with a barrel vault, and side columns with composite capitals. The original coffered surface of the vault is still in place, as are the bas-reliefs on the inner walls of the vertical supports; they represent the conquest of Jerusalem by Titus and his triumphal entry into the city. The morphology of the

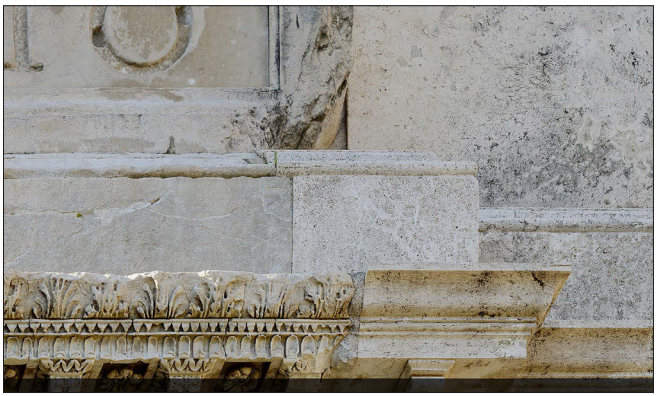


Fig. 3 - The process of simplification of the architectural order in the decorative motifs and in the use of materials.

Fig. 4 - The planimetric representation of the georeferenced topographical survey.

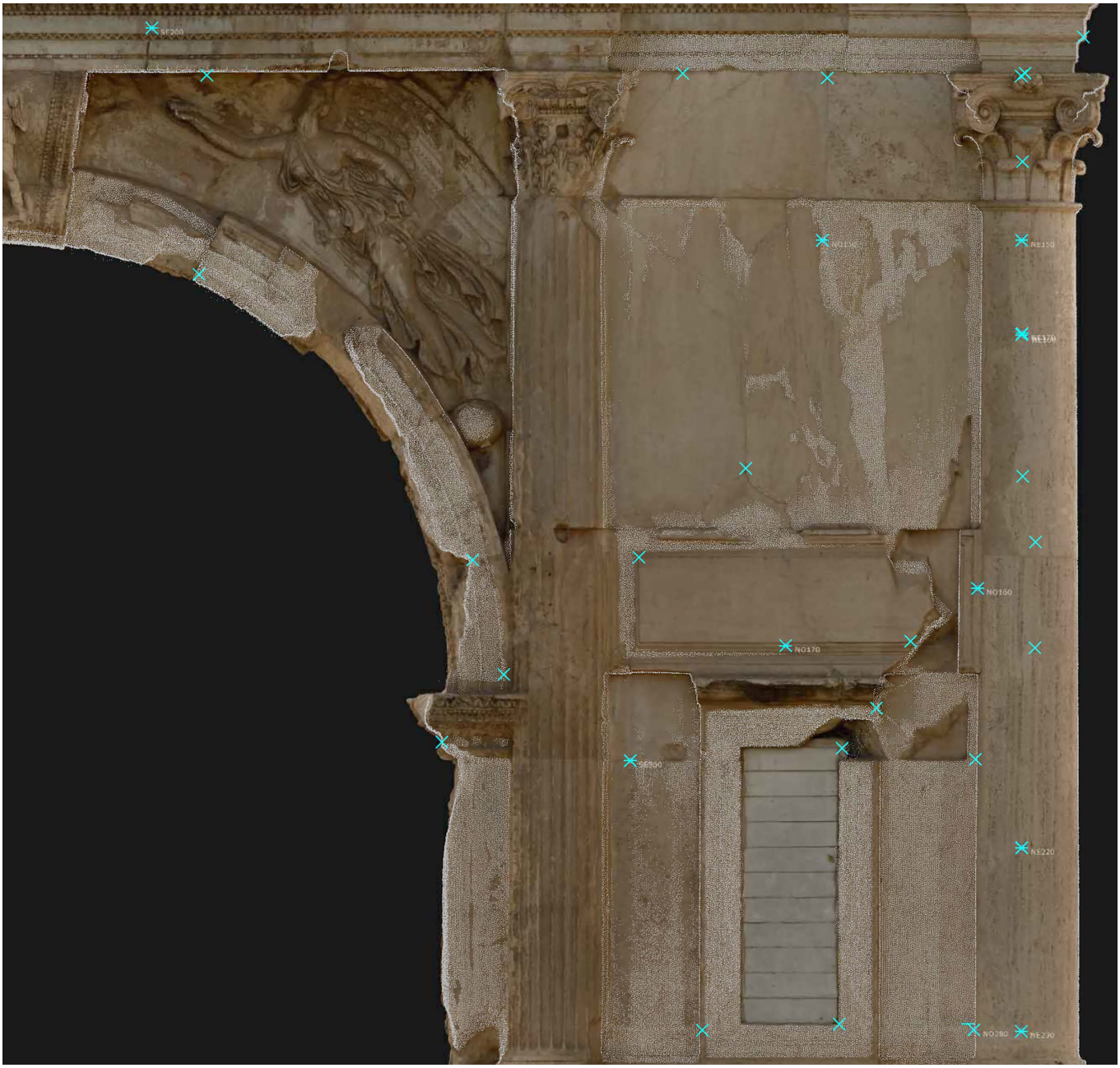
Fig. 5 - The topographical fiducial markers overlayed to the mass acquired data and to the very high-resolution image.

arch remained intact after restoration since only the decorative details had been simplified, making the new parts easy to recognise compared to the original elements (fig. 3). The correct methodological approach in any study, in this case that of the Arch of Titus, which underwent important changes over the years, requires a multifaceted and well-structured survey campaign, one that highlights several of its elements and peculiarities.

The campaign involved the complex integration of the following phases:

- 3D laser scanner survey;
- fhotographic acquisition and IBM-SfM restitution, terrestrial digital photogrammetry and aerial photogrammetry;
- acquisition of gigapixel orthophotos;
- experimental acquisition involving sample testing;
- georeferenced topographical survey (linked to the Roman Forum-Palatine GPS network).

The initial phase of the study involved massive and, to a certain extent, objective acquisition, automatically acquired using a 3D laser scanner and digital aerial and terrestrial photogrammetry. This provided a huge amount of data that was crucial when constructing the texturised numerical model of the monument. The ensuing use of gigapixel images provided further refinement of the documentation regarding the studied surfaces which could then be illustrated on a 1:1 scale. The second phase entailed using a topographical survey in order to achieve non-automatic subjective acquisition; in fact the operator critically chose which points to link on the monument, thus retaining control over the points during the ensuing phases. This required the establishment of a hierarchy of the elements that make up the object and a semantic structurisation of its parts. The massive data had to be combined with the accurate topographical data in order to orient and control the surveyed data; the goal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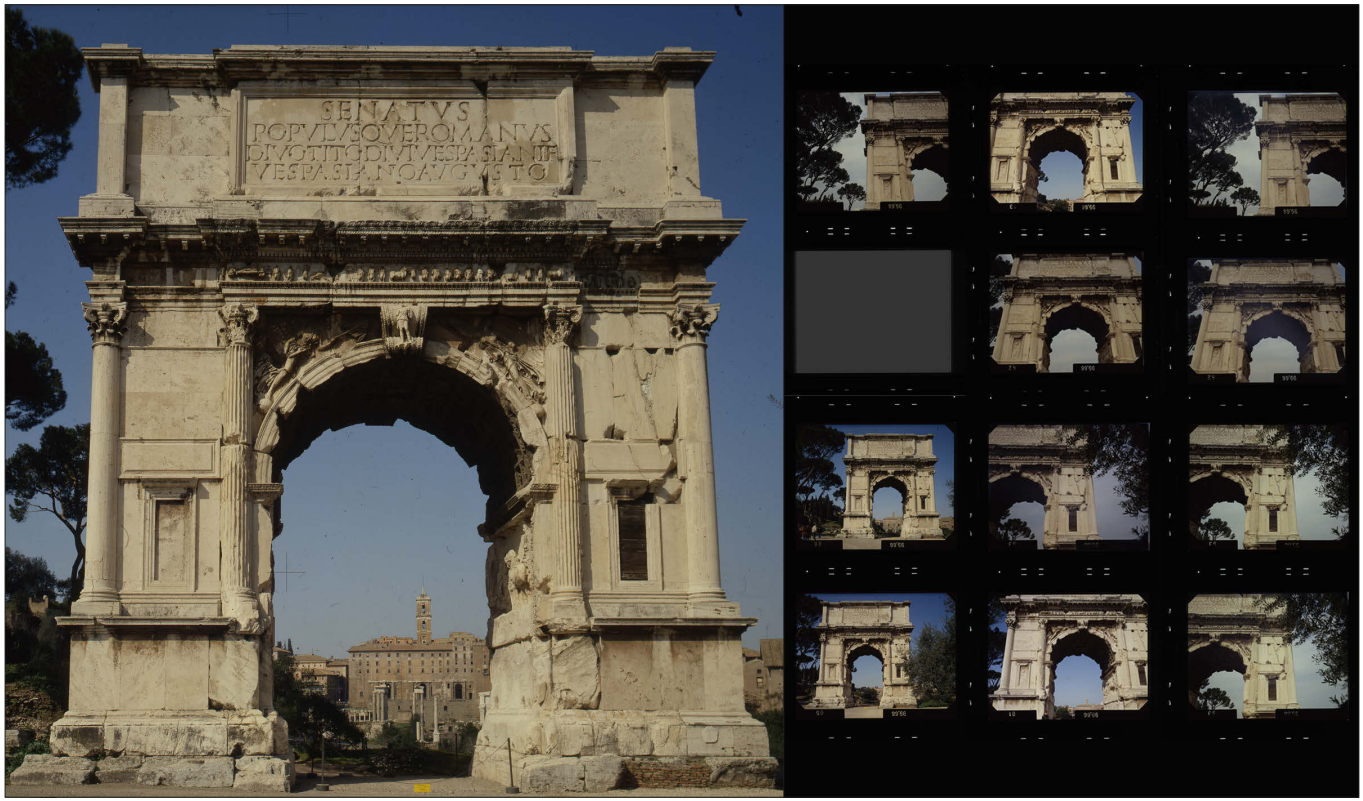
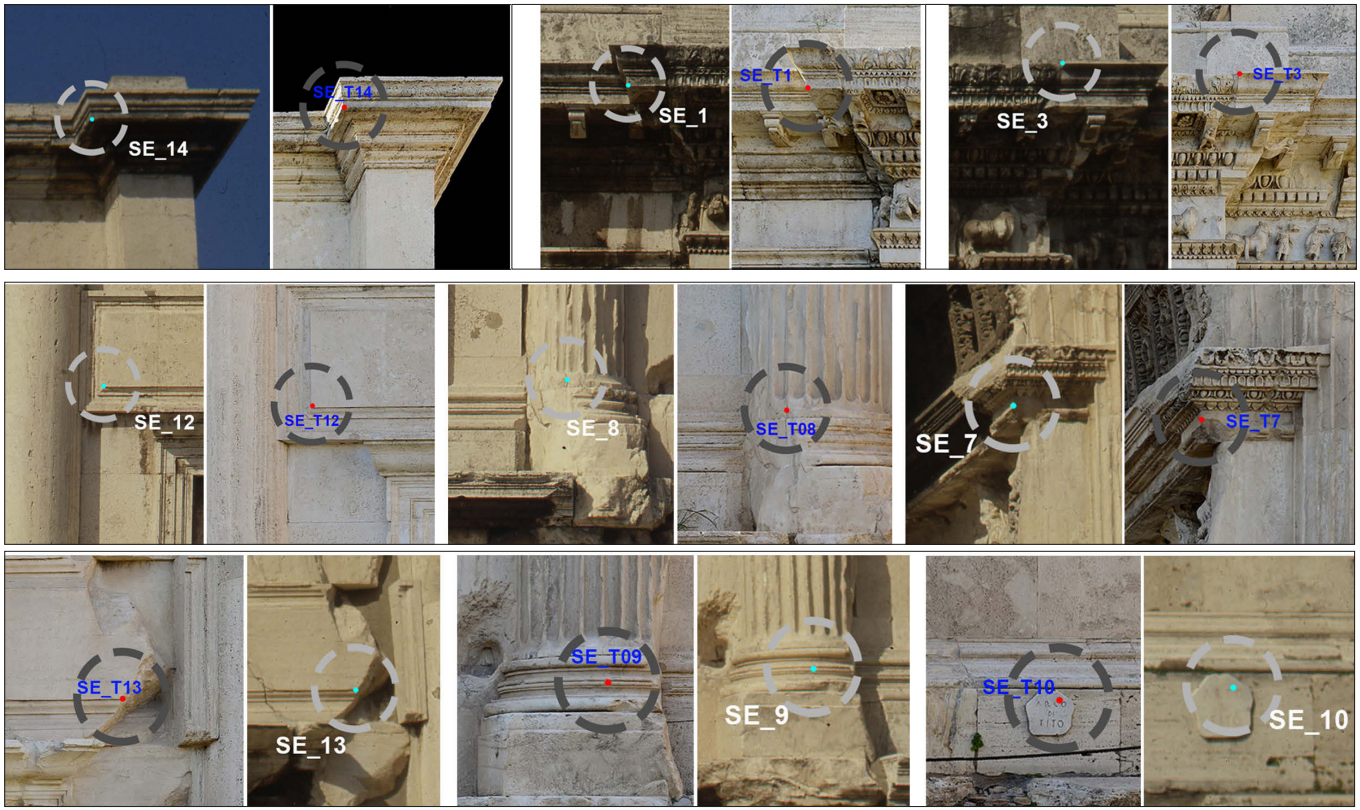


Fig. 6 - The topographical survey of the monument performed in the nineties by Professor Alessandro Sartor.

Fig. 7 - The comparison between the two topographical surveys after the re-collimation process of the same fiducial markers.

was to find a univocal orientation from amongst the acquisition methods, but it also helped to define the geometric and ideal representation of the monument. This enabled data systemisation and a comparison between the aforementioned data acquisition methods; the objective was to produce a solid, reliable integrated system. After the data has been normalised – one of the primary goals of the research – it will be inserted into a multiple, integrated model – a HBIM model – containing both the geometric data (from the numerical model) and informative data. This type of structure makes it possible to specify the ontology of each element and the system of relations between the parts, based on an absolute reference hierarchy.



Topographical Survey, a Critical Comparison

The objective of this contribution was to validate the acquired data and perform a synchronic and diachronic comparison using a georeferenced topographical survey[4] (fig. 4). This involved pre-emptively performing a critical selection of certain key points, based on very precise criteria: monitoring the 'state of health' of the monument over the years, and studying the partition of the elements of the arch. These points were collimated to establish the univocal direction of the clouds, but also to manage the data from the mass acquisition systems. At any time in the future, the key points that were identified and measured can be compared in order to verify possible transformations and adjustments of the arch; they can also help in the development of the ideal and geometric representation of the monument. This provided greater control over the study of the architectural order, the mouldings, and their semantic study. It involved creating a system of fiducial markers as a further element to test the mass acquired data (fig. 5). An accurate survey to reconnect and retest all the

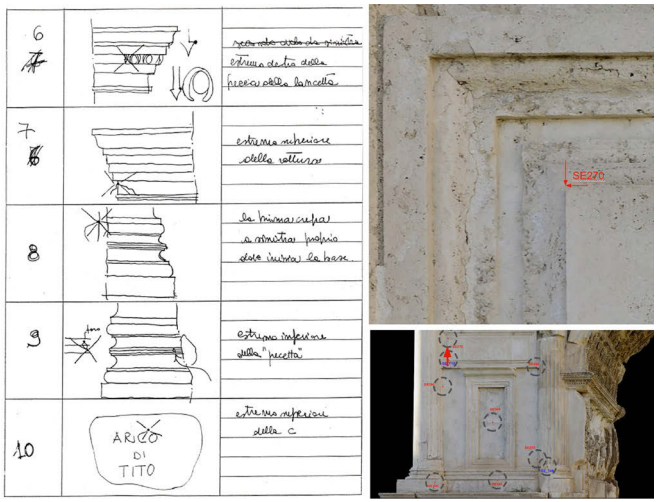
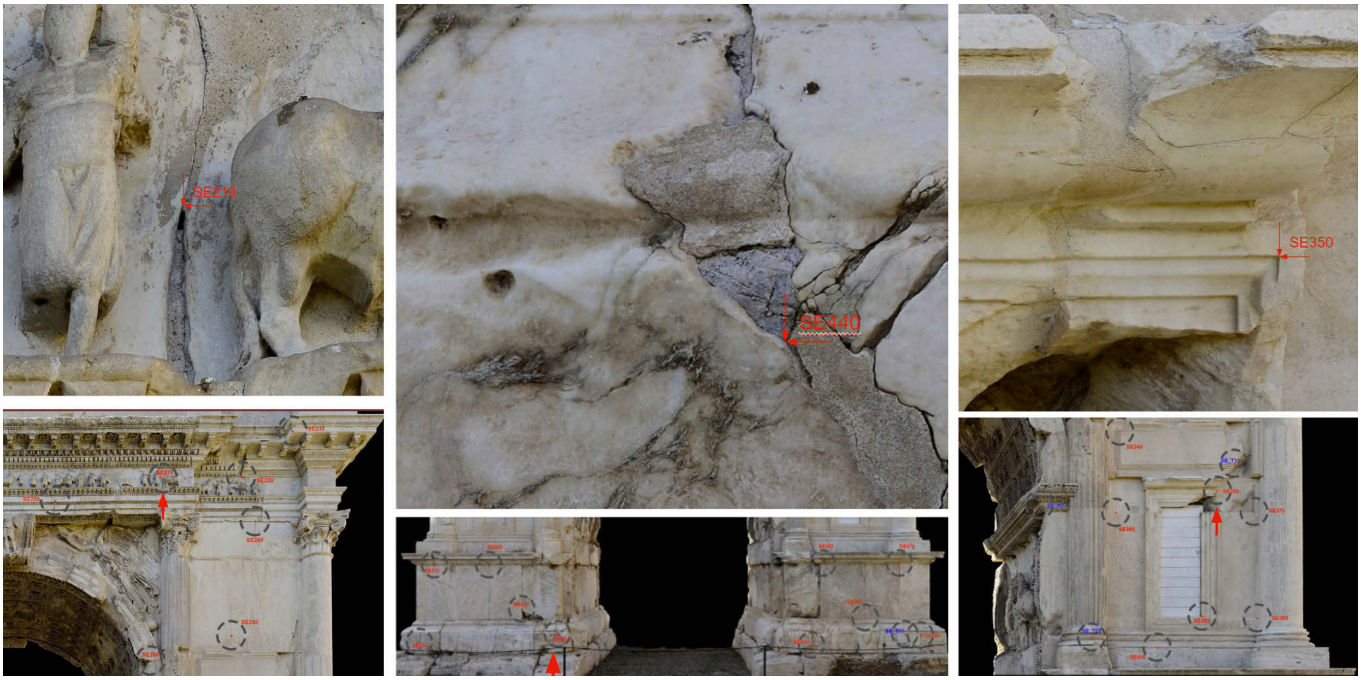


Fig. 8 - The comparison between the two monographies of the points.

Fig. 9 - The calculation of the average deviation between the two surveys, in 1993 and in 2020.

Fig. 10 - The monographies of the points in the contemporary survey: the points are selected in the very high-resolution image.

	1993			Dist 1993	2020			Dist 2020	Differenza 1993-2020
Codice	x	y	z		x	y	z		
1	3,3029	-16,3759	9,4142	8,783	6266,5961	3027,7385	40,945	8,791	-0,008
7	10,1145	-17,5867	4,003	6,465	6259,8523	3029,3149	35,53	6,474	-0,009
8	3,9837	-16,9075	2,0673	6,817	6265,7615	3027,5164	33,592	6,826	-0,009
9	10,7916	-17,2531	1,9626	3,684	6259,3576	3029,8784	33,491	3,696	-0,012
10	13,3322	-16,993	-0,6929	12,781	6257,1228	3031,1327	30,828	12,798	-0,017
12	1,703	-17,0415	4,6095	11,250	6267,8034	3026,4933	36,137	11,264	-0,013
13	12,9332	-17,7104	4,6067	8,845	6257,2059	3030,3091	36,139	8,854	-0,009
14	13,0624	-17,2204	13,4374	10,590	6257,2767	3030,8169	44,978	10,611	-0,021
Codice	x	y	z		x	y	z		
7	10,1145	-17,5867	4,003	8,451	6259,8523	3029,3149	35,53	8,459	-0,008
12	1,703	-17,0415	4,6095	17,736	6267,8034	3026,4933	36,137		
Codice	x	y	z		x	y	z		
10	13,3322	-16,993	-0,6929	9,748	6257,1228	3031,1327	30,828	9,764	-0,017
8	3,9837	-16,9075	2,0673	17,493	6265,7615	3027,5164	33,592		



data, thereby providing reassurance re the monument's state of health, at least dimensionally. The comparative analysis between the current topographical survey of the monument and the one performed in the nineties by Prof. Alessandro Sartor turned out to be extremely interesting since it helped in the observation and definition of the micro-variations that had occurred in the last thirty years. The material gathered during this survey included eleven, 10 x 15 cm photographic plates of the south-east elevation of the monument (fig. 6). The points collimated and inserted in Sartor's campaign handbook in turn became part of the current survey project, making comparison possible after re-collimation (fig. 7). The two monographies of the points were compared; the former manually drafted in 1993 (the year Sartor performed the survey) using preparatory sketches of the details, the latter based on the gigapixel images acquired during the current survey campaign. In the handwritten monograph the point was codified, represented and described, while in the contemporary survey it was identified directly on the very high-resolution image (fig. 8).

After an initial on-site inspection, it was clear that no micro-variations of the selected points had taken place. This theory was tested by superimposing the two surveys after roto-translation and calculation of the average deviation between the two. An average error of roughly 1 cm is present on the coordinates x,y,z; this is acceptable considering the years that have passed between the two surveys (fig. 9).

It is important to emphasise the critical points regarding the two surveys:
- interpretation of the selected points. The handwritten monograph cannot by univocally and objectively interpreted because the selected point was difficult to identify and had to be interpreted at the operator;
- instrumental inconsistency due to different topographical acquisition methods. In 1993 the topographical survey used forward intersection; every point was collimated from a pair of stations and even the angles were calculated. Today we use the polar coordinates method and the point is collimated using a single station;
- variation in the climate and temperature during the two surveys. On 6th March 1993 the temperature was 12°, while on 1st October 2020 the average temperature was roughly 23°, a difference of 11° which would justify reasonable deformation in the marble or Roman concrete.
The topographical points were connected to the Roman Forum-Palatine GPS network after identification of the points (*V24* and *V26*) using a monographic technical sheet of the point with its FUR coordinates These geographical monographs help to identify the GPS point of the Forum network as well as establish the point thanks to a photograph, a CAD drawing, and a brief description of its location. Interpretation of the point is again subjective; the surveyor's skills can influence the recognisability of the point which may in turn lead to an error.
Therefore, using the gigapixel image to objectively locate the point ensures safe transmission of the surveyed data over a period of time. To draft the current monographs a decision was taken to adopt a two-step approach: initial identification of the point in a generic abacus, divided according to the elevation of the monument and semantic group (e.g., attic, arch, base, etc.), followed by a detailed localisation of the point, on an almost 1:1 scale. The points selected on the monument belong to two groups: the first level involved the architectural partition of the monument, while the second level involved its material characteristics (fig. 10).

Conclusions

In this case the topographical survey was an opportunity for discussion which, together with the mass acquisition of data, made it possible to put together more information about the project. It also ensured greater accuracy in the study of the mouldings and allowed for a critical interpretation of the semantic study of said mouldings (proportioning of their elements); this was performed by critically comparing the two surveys. Clearly this involved updating a procedure that is already well-structured and has been used at length in the field of architectural survey. Once again, an accurate qualitative survey, rather than a quantitative survey, is confirmed as being the most up-to-date tool used in general testing and in the integration and normalisation of heterogeneous data from points clouds surveys (3D laser scanner or Image-Based Modelling). It is a solid element used to combine the massive data that is collected and helps in its normalisation. It is also a reliable, reassuring tool to compare past and present measurements when trying to accurately verify changes to the monument, thus highlighting the importance of time in all the processes documenting our existing heritage. Even the interoperability of the players involved in the study of an object temporarily becomes 'transversal'; it adds a semantic potential to the reconstruction of the model by inserting a new piece of the puzzle based on the management of survey data over a period of time.

Notes

1. The research on the Arch of Titus is entitled: *Experimental knowledge-gathering models for integrated survey and digital representation: the case study of the Arch of Titus in the Archaeological Park of the Colosseum*; scientific director, prof. Graziano Mario Valenti. The research was jointly performed by the Department of History, Drawing and Restoration of Architecture, Sapienza University of Rome and the Archaeological Park of the Colosseum; special thanks to Federica Rinaldi.

2. The survey campaign, performed at different moments in time, by all members of the research group, began in 2019 and ended with the topographical survey performed in September-October 2020.

3. Related to the bibliographical sources on the subject of Stern-Valadier restoration, the following must be mentioned: Valadier 1822; Valadier 1828; Valadier 1833; Brües 1958; Marconi 1964; Casiello 1973; Debenedetti 1979, Pfanner 1983.

4. On this subject, it is necessary to quote from Docci, Maestri 2009.

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10 VISUAL RELATIONSHIP ANALYSIS: ALGORITHMIC MODELLING AT THE SPATIAL AND URBAN SCALE

MATTEO FLAVIO MANCINI

Abstract

The potential of algorithmic modelling as an analytical tool was tested in the context of research conducted on the cultural landscape of Manziana (RM), a 16th-century city of foundation. The city of Manziana was established on the Arcispedale del Santo Spirito initiative, which commissioned the architect Ottaviano Mascherino in 1589-1590. The theme investigated in this contribution concerns the evaluation of visual relationships at the territorial and urban scales. The former is used to evaluate the relationships that the foundation site establishes with the surrounding territory and Lake Bracciano. At the same time, the latter allows analysing the perceptual impact of the transformations undergone by the foundation nucleus of the town through the comparison of three configurations: the original project, which was never fully implemented, the conformation of the square attested by the Gregorian Cadastre in the 19th century and the current situation.

Nell'ambito delle ricerche condotte sul paesaggio culturale della città di fondazione cinquecentesca di Manziana (RM), sono state sperimentate le potenzialità della modellazione algoritmica come strumento di analisi. La città di Manziana deve la sua fondazione all'iniziativa dell'Arcispedale del Santo Spirito che incaricò del progetto l'architetto Ottaviano Mascherino nel 1589-1590. Il tema indagato in questo contributo riguarda la valutazione delle relazioni visuali alle scale territoriale e urbana. La prima viene utilizzata per valutare i rapporti che il sito di fondazione instaura con il territorio circostante e il lago di Bracciano, mentre la seconda permette di analizzare l'impatto percettivo delle trasformazioni subite dal nucleo di fondazione del centro abitato attraverso il confronto di tre configurazioni: il progetto originario, mai completamente attuato, la conformazione della piazza attestata dal Catasto Gregoriano nel XIX secolo e la situazione attuale.

The experimentation presented in this paper is part of the research[1] carried out on the town of Manziana (Rome) and its cultural landscape, the Tuscia Romana, i.e. the area of Lazio that includes the northern part of the province of Rome with the lakes of Bracciano and Martignano. In particular, this essay investigates the role of visual relations at the territorial and urban scale, with two different aims: identifying the relations between the foundation site of Manziana and the surrounding territory and the perceptive analysis of the transformations undergone by the urban node of Piazza Tommaso Tittoni. The analysis of the visual relationships was conducted through algorithmic modelling to experiment with its use as an analysis tool.

Foundation cities in the Patrimony of St. Peter and the case of Manziana

The area of Tuscia Romana corresponds to the southern part of the Papal States known as the Patrimony of S. Peter[2]. The Pope carried out the administration of this territory in two ways: an indirect one, thanks to the entrusting to subjects such as noble families and charitable institutions such as the Arcispedale del Santo Spirito; a direct one, carried out through the activity of the Camera Apostolica.
In the 16th century, this area experienced a moment of economic expansion, which also translated into extensive urbanistic and building activity. The richness of specific natural resources, such as the alumite quarries in the Tolfa mountains, and the abundance of wood from the forests that covered the territory, were among the reasons for the interest of many subjects in this Lazio area. After the Sack of Rome in 1527, the achieved political stability created the socio-cultural conditions for the settlement of summer residences and real extra-urban palaces of the most important Roman families.
In this context, three types of interventions on the region's settlement fabric can be recognised: the modernisation of medieval centres into Renaissance style; *extra moenia* planned extensions; and the foundation of new villages for managing the territory[3]. This last typology finds a significant concentration of cases in the territorial strip that goes from the Tyrrhenian coast, in correspondence with the Civitavecchia port, includes the strip of the Tolfa mountains and reaches the lakes of Bracciano and Martignano. Here, thanks to the action of different subjects, several villages were founded in a few decades: Rota (1550-1592) and Oriolo Romano (1578-1585) on the initiative of the Santacroce di Vejano; Allumiere (1580) by the Camera Apostonica[4]; Manziana (1589-1590) and Castel Giuliano (1664) by the Arcispedale del Santo Spirito (fig. 1). The foundation of Manziana took place between 1589 and 1590 according to the design of Ottaviano Mascherino, architect of the Arcispedale del Santo Spirito, through the construction of its central nucleus: the square overlooked by both the palazzo del Santo Spirito and the church of San Giovanni Battista (today Piazza Tommaso Tittoni)[5]. The foundation's site is located on the eastern slope of the hills immediately adjacent to the western shores of Lake Bracciano and about 15 km from the Tyrrhenian coast. The original project was implemented at the foundation level but only partially realised from an architectural perspective. It is still testified by the project drawings preserved in the Fondo Mascarino of the Historical Archive of the Accademia Nazionale di Santa Cecilia in Rome[6]. The study of these drawings, previously carried out as part of the research (fig. 2), has allowed a three-dimensional reconstruction of the project[7] that is the object of the analyses at urban scale of this contribution together with those at a territorial scale.

Visual relationships and the criterion of intervisibility

The analysis of visual relationships is a powerful tool for knowledge and understanding of the reality around us[8] because it makes it possible to treat in graphic and measurable terms aspects that would otherwise be

exquisitely qualitative, such as those linked to the visual perception of the territory and urban spaces.
The visual experience activates the process of 'symbolisation' and man's identification with the territory[9], while vision is the first tool for measuring and verifying the design. Perspective can be considered the geometric counterpart of the optical-visual process and has been one of the architects' design tools since the Renaissance. The design importance of perspective is confirmed in the late 16th-century experiences of foundation and re-foundation[10] mentioned above.

The analysis of visual relationships is therefore meaningful at different scales because, on the one hand, it relates human settlements to their respective territories and, on the other hand, it allows to analyse the perceptual values of settlements in relation to the people who inhabit them.
These analyses can be carried out by applying the criterion of intervisibility between points, i.e., through geometric operations that check whether two points are mutually visible or whether there is any obstacle between them.

Fig. 1 - The figure represents the territory of Tuscia Romana with the foundation towns built between the 16th and 17th centuries.

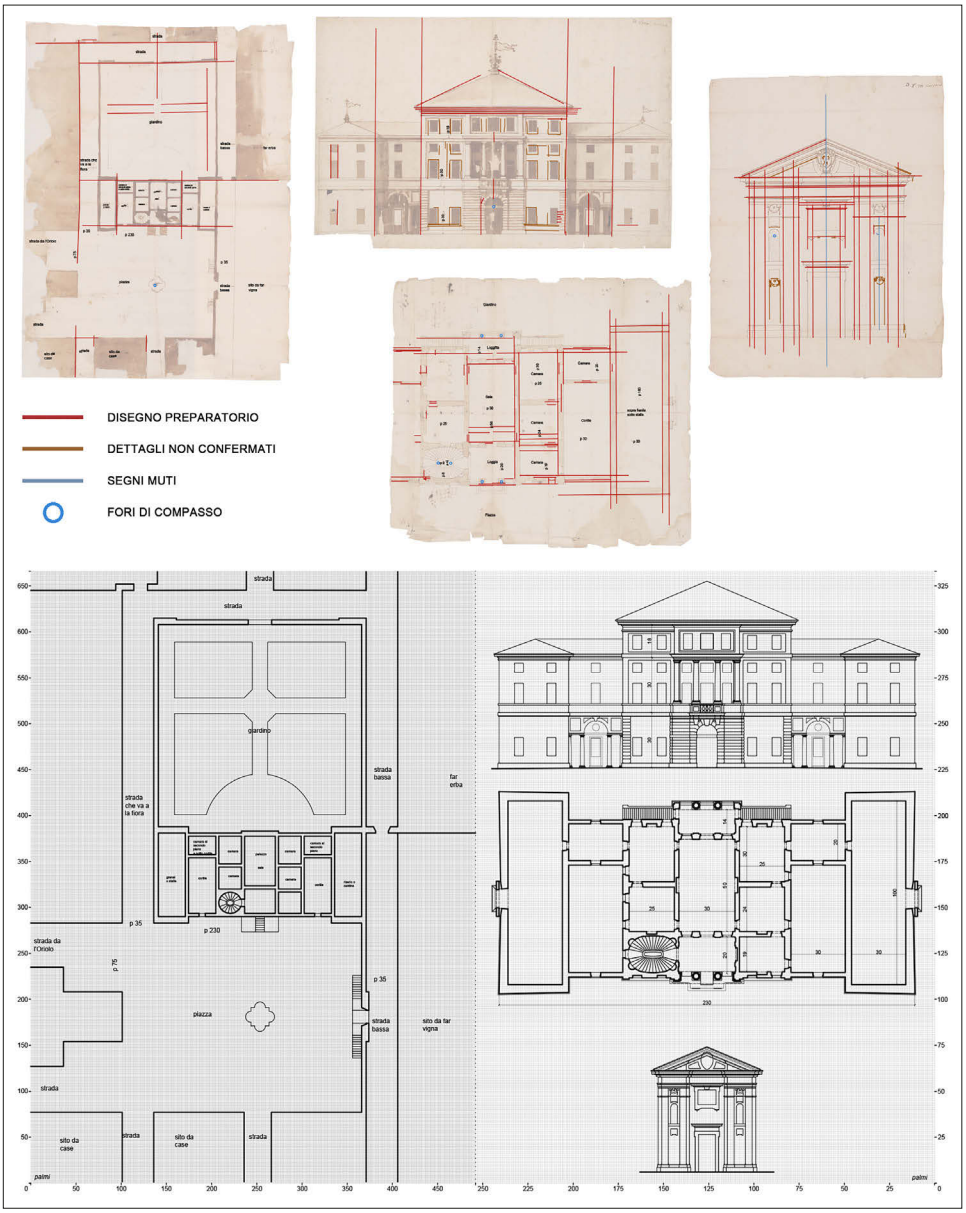


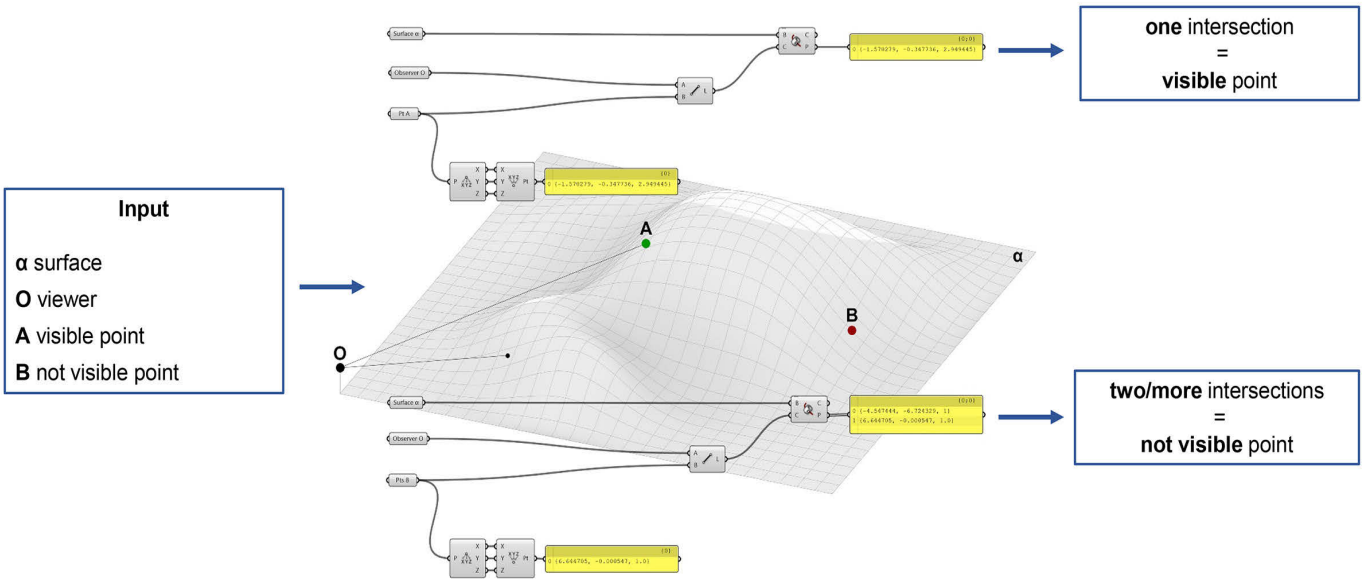
Fig. 2 - The analysis on drawings by Mascherino for Manziana: the construction signs in the original drawings (above); the critical transposition of the drawings (below).

Fig. 3 - The basic algorithm that determines the intervisibility condition between points.

The essential condition of intervisibility from an algorithmic point of view can be effectively represented through the number of intersections of the visual ray:
- if the visual ray, which connects the analysed points to the observer O, returns only one intersection, this intersection will correspond to the observed point itself, and then it will be a visible point;
- if the visual ray returns any number of intersections greater than one, the analysed point will not be visible[11] (fig. 3).

The structure of the algorithm

The algorithms used for analyses at different scales share a basic structure consisting of three functional blocks that perform specific tasks (fig. 4):
- Block A generates the three-dimensional model to be analysed using different inputs while identifying the point(s) of view is done by indicating them directly on the model. In territorial scale analysis, the inputs are GeoTIFF satellite images and OSM (Open Street Map) data: the former are used for modelling the topography while the latter provide data for tracing artificial structures. For urban scale analysis, the input is instead a three-dimensional model treated to consist of a single polysurface. This block is also responsible for creating the grid of analysed points on the model's surface through its intersection with two arrays of orthogonal and equidistant vertical planes;
- Block B performs the intervisibility analysis by performing three operations: it traces the visual rays; it locates the intersections between the visual rays and the polysurface; it counts the number of intersections for each ray;
The outputs of this block are the intersection points and the numbers of occurrences for each analysed point, the latter represented by data lists;
- Block C generates the analytical and graphic



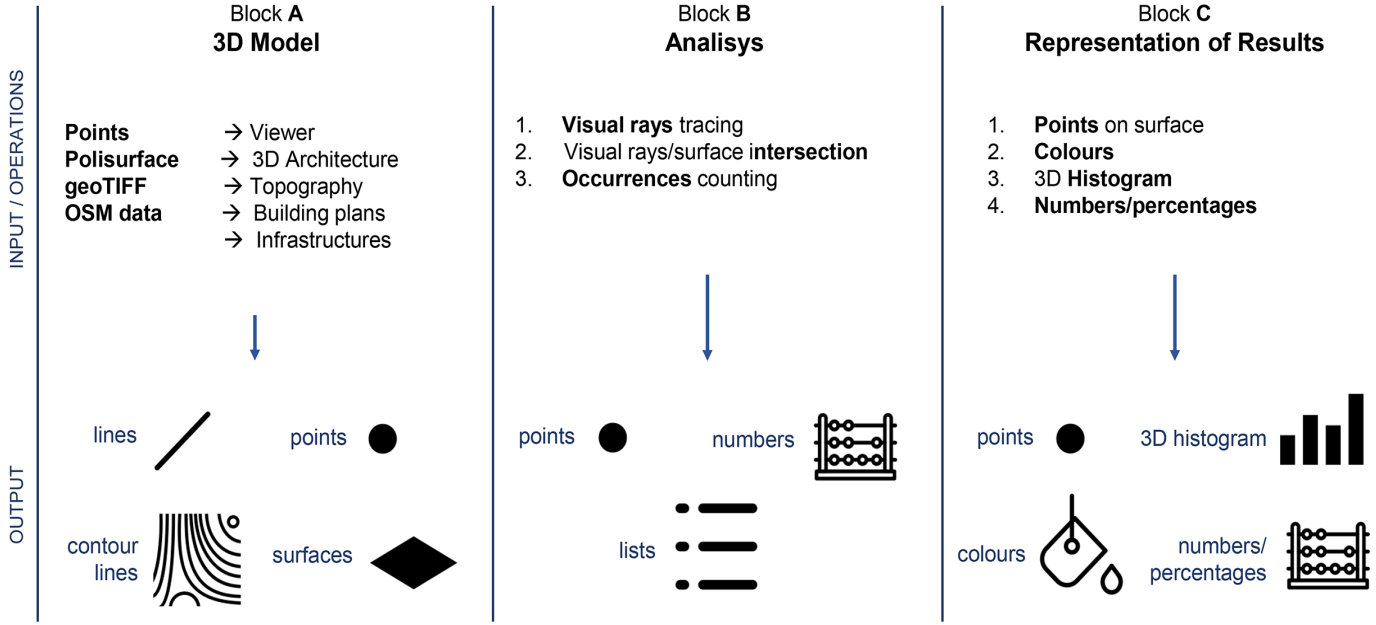


Fig. 4 - The logical outline of the structure of the algorithms adopted in the experimentation.

Fig. 5 - The part of the territory covered by the intervisibility analysis and the seven considered settlements.

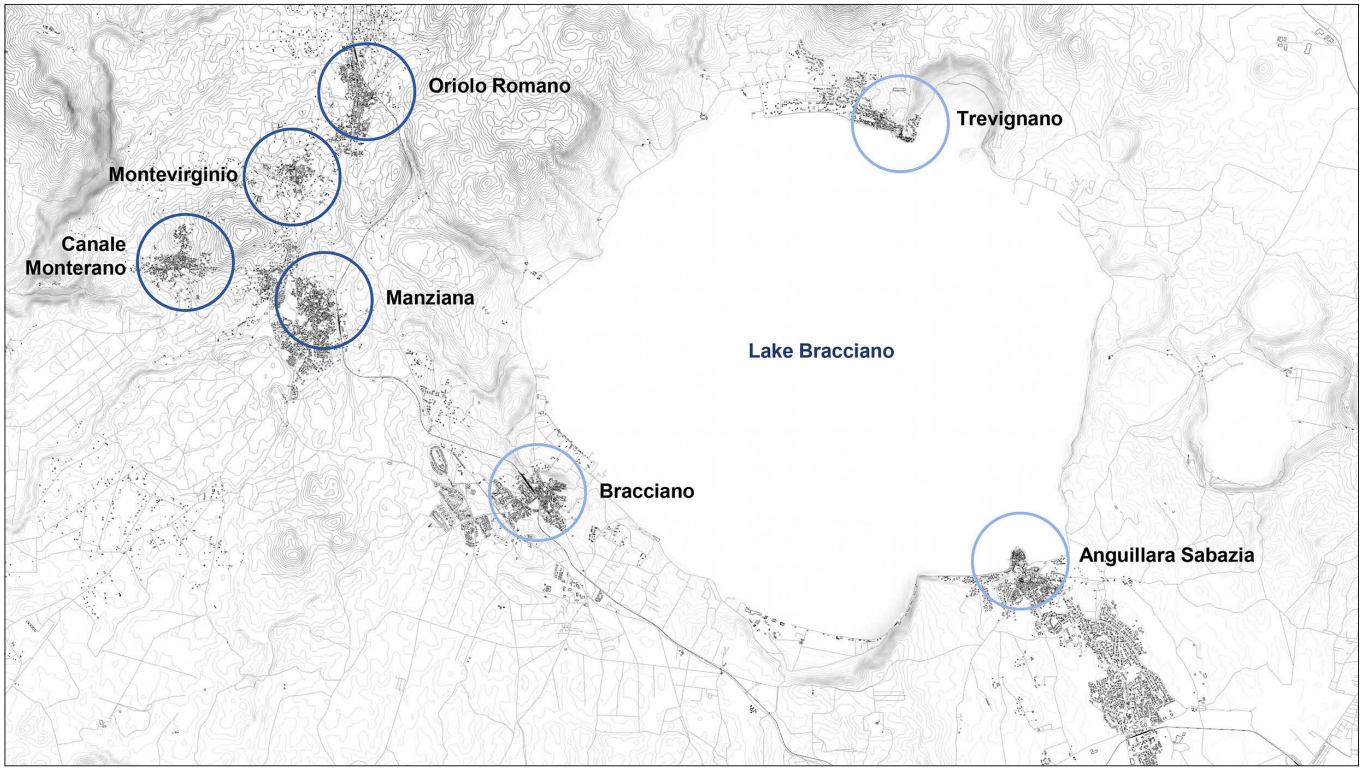
representations of the analysis results. The former are lists composed of the absolute number of visible points and the respective percentages to the total number of analysed points, while the latter can be of two different types. A first representation is composed of points, which coincide with the analysed points, coloured according to their condition of intervisibility.

A second representation, which is more abstract than the previous one because it maintains the planimetric position but not the altimetric location of the analysed points, is composed of a coloured three-dimensional histogram in which the height and the colour of the columns represent the number of viewpoints from which the analysed point is visible.

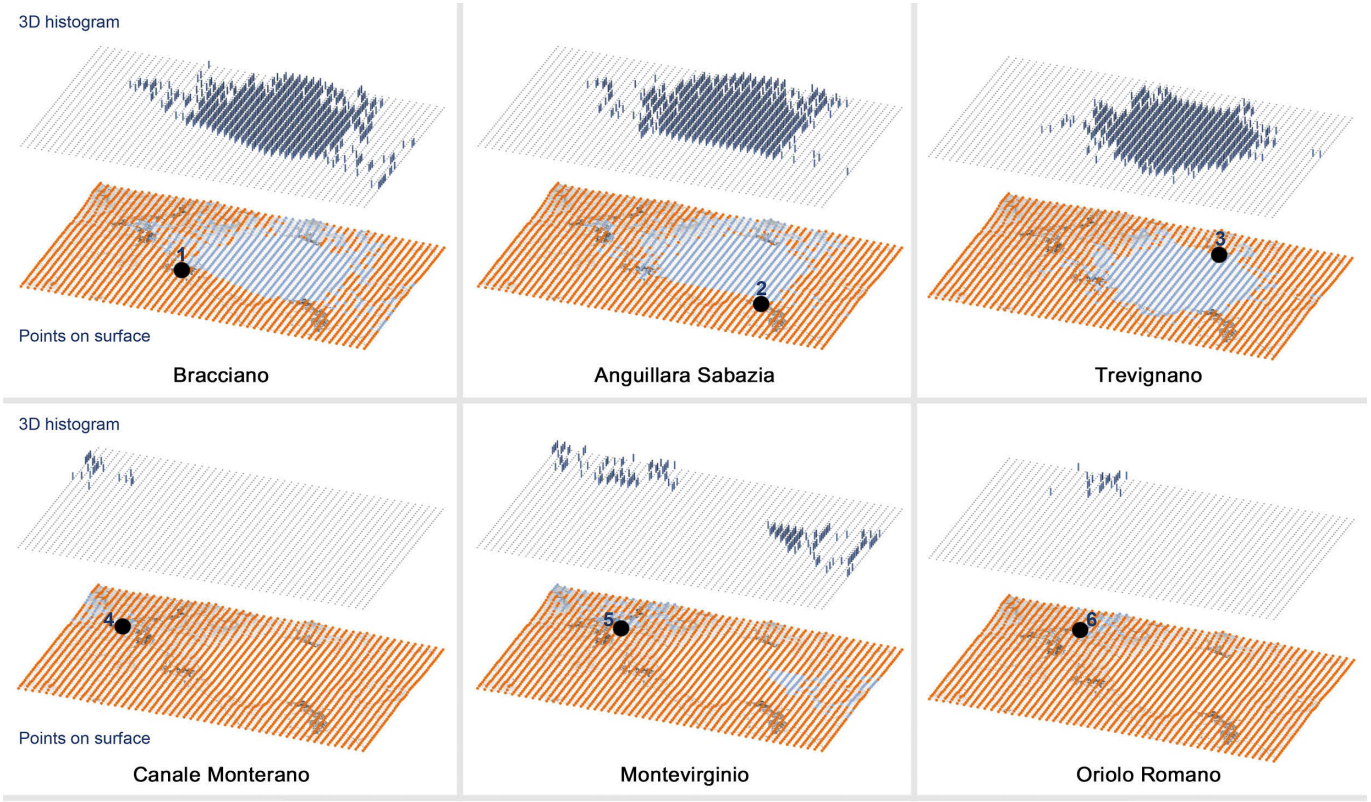
This second representation is handy in the case of analyses conducted from several simultaneous observation points.

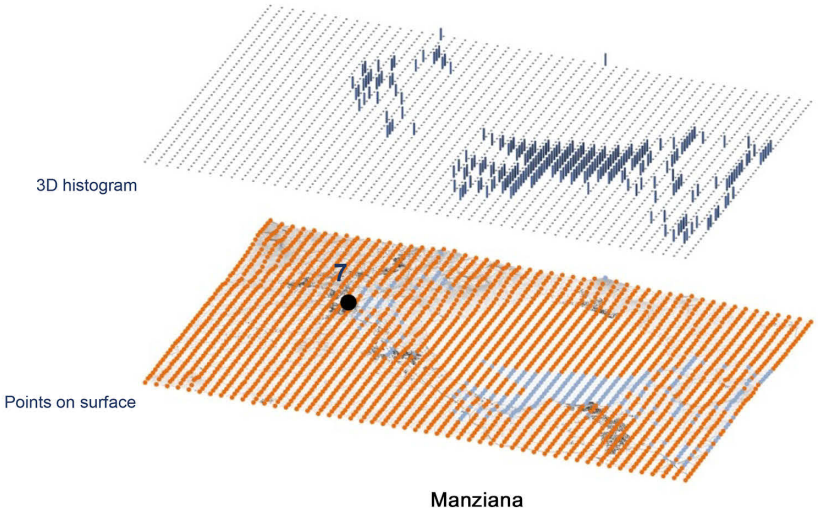
Visual relations at territorial scale

The analysis of intervisibility at a territorial scale was carried out on a portion of territory that includes Lake Bracciano and the hills immediately adjacent to its western shores. Seven settlements fall within this territory. Significant points of these settlements, such as the main squares, were chosen as observation points (fig. 5).



The analyses performed from the individual settlements revealed two types of visual relationships between the villages and the territory.
A group of settlements – consisting of Anguillara Sabazia, Bracciano and Trevignano – showed solid visual relationships with the lake basin, as we could expect given their coastal position, and showed a total absence of relationships with the surrounding area due to the rapid altimetric growth of the lake shores. Another group of settlements – to which Canale Monterano, the Hermitage of Montevirginio and Oriolo Romano belong – shows a total absence of visual relations with the basin and a tendency to relate to the northwest territories even though they are located immediately behind the lake. Among the settlements on the hills, which share the same foundation or important renovations histories, Manziana is the only one that establishes a significant visual relationship with the lake. In fact, the analysis has shown a clear visual relationship with the south-eastern shores of the lake and other, less significant, relationships with the northern shores. This characteristic makes unique the foundation site of Manziana among the centres gravitating around the shores of Lake Bracciano (fig. 6).
Two analyses were also carried out from multiple viewpoints. The first concerned the Olmata avenue, which connects the Altieri Palace in Oriolo Romano with the village of Montevirginio, located at the foot of Mount Sassano. In


3D histogram
1
Points on surface
Bracciano
2
Anguillara Sabazia
3
Trevignano
3D histogram
4
Points on surface
Canale Monterano
5
Montevirginio
6
Oriolo Romano


3D histogram
7
Points on surface
Manziana

this case, eight viewpoints equally distributed along the 4Km straight road were taken into consideration. The analysis showed that, due to the orographic conformation of the straight road, the walker has visual relationships exclusively with Altieri Palace and the Hermitage situated on the slopes of Mount Sassano. In contrast, he has none with the rest of the surrounding territory.
These results prove the design intentions of the commissioners, the Altieri family, who were lords of both Oriolo Romano and Montevirginio in the 17th century and who wanted to symbolically underline the link between the family, the two villages, the territory, and the sacred place of the Hermitage.
The second test involved the simultaneous analysis of the area from the seven settlements to assess which part of the territory is most strongly linked to the human settlements gravitating around Lake Bracciano. The result showed that the part of the territory with the most significant visual relations with the settlements is that of the south-eastern shores of the lake. This result could support the hypothesis regarding the existence of alignments oriented towards Rome at a territorial scale[12] (fig. 7).

Visual relations at the urban scale

The intervisibility analysis was then applied at the urban scale to evaluate the perceptual impact of the transformations undergone by the foundation nucleus, today's Piazza Tommaso Tittoni. The three-dimensional models to be analysed were carried out based on different sources: Mascherino's drawings were used to reconstruct the three-dimensional model of the foundation project; the building consistency attested by the Gregorian Cadastre

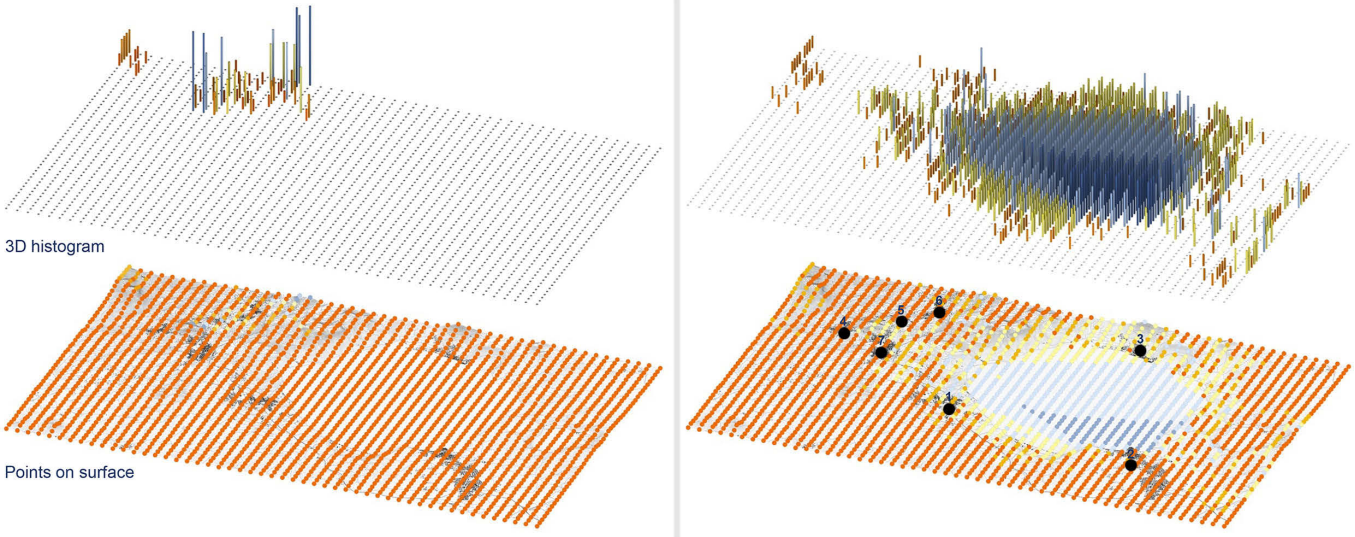
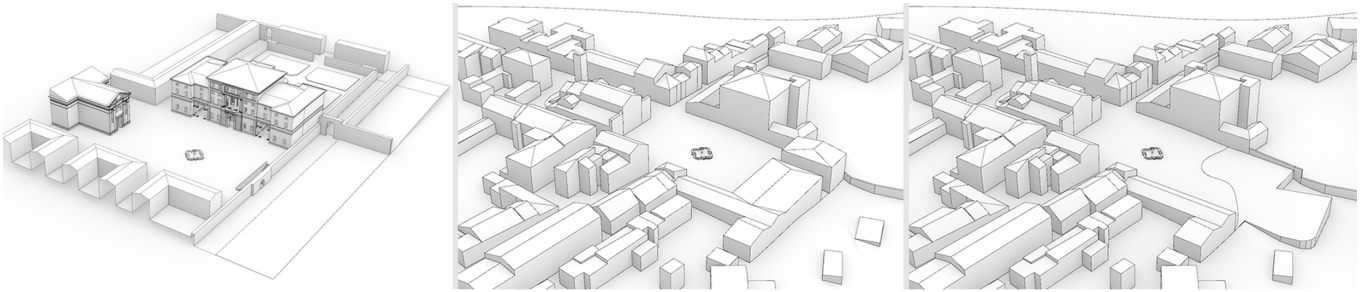


Fig. 6 - The results of the intervisibility analysis at territorial scale from an individual point of view.

Fig. 7 - The results of the intervisibility analysis at territorial scale from several simultaneous points of view.

was reconstructed from the map of the nineteenth-century cadastre and the integrated survey of the actual state; the model of the current situation is based on the integrated survey of what is now present in Manziana.
The comparison between the three phases highlights the continuity existing between the foundation project and the current configuration, especially regarding the overall layout and the palace on the north side of the square, the church on the west side and the residences on the south side. The western side of the square has undergone the most transformations: in Mascherino's project, it was envisaged as a side closed off by a wall and a staircase; in the Gregorian cadastre, however, it appears cluttered by a thick building block; today it is completely open, like a panoramic view towards the lake (fig. 7).
The analysis at urban scale was carried out for the three phases taking into consideration the three main accesses to the square: the one from the south, from the current Via Roma, the one from the west, through the current Corso Vittorio Emanuele, and the one from the east, coming up from the train station. Comparing the quantitative results is helpful to determine which entrance offers the broadest view of the complex and, therefore, to evaluate how much the transformations that have occurred to the original project have interfered with Mascherino's initial intentions. The evaluation of the results assumes that the preferred access of each configuration is the one that ensures the widest view of the architectural-urban complex.
The first emerging result is that the design conceived by Mascherino was perceptually more balanced than what was actually built. In fact, the number of visible points from the respective entrances varies considerably less, with variations within 100 points, compared to the other two analysed phases, which instead show considerably more significant variations. In particular, the phase attested by the Gregorian cadastre shows a substantial equivalence of the south and east entrances, while the one that returns the highest result is the one from the west (932 points). The latter can be considered as the perceptually privileged entrance. On the contrary, the current state appears the most unbalanced, with a substantial prevalence of the east entrance (1926 points) due to its complete opening towards the territory to the east and south.
We can also observe that the preferred entrances of Mascherino's project were those from the south, oriented towards the palazzo del Santo Spirito, and those from the east, aligned with the façade of the San Giovanni Battista Church. This characteristic was wholly altered in the 18th century, while today, the prevalence of the east entrance appears to partially recover the importance assigned by Mascherino to this direction of access (fig. 9).



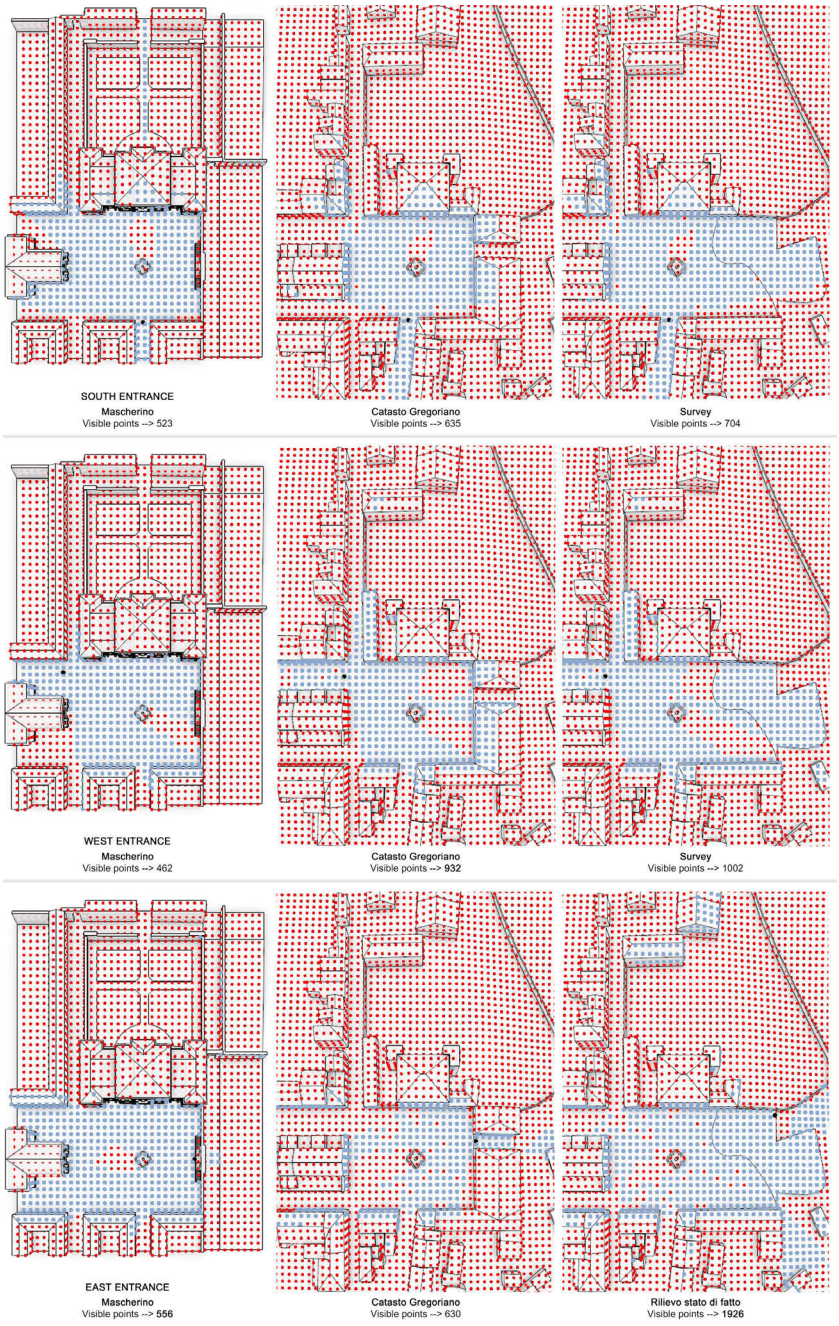


Fig. 8 - The three-dimensional models of the three analysed spatial configurations.

Fig. 9 - The results of the urban scale intervisibility analysis from an individual point of view.

Conclusions

The results of the intervisibility analyses provided useful data for interpreting the urban transformations that occurred on the foundation nucleus of Manziana. It shows that the original project was significantly balanced concerning the different accesses, with a slight preference for the east entrance, while the subsequent configurations present more evident preferences, the west access in the 18th century and the east one nowadays.
The discussion of the results provided by the algorithms for the analysis of intervisibility shows the effectiveness of algorithmic modelling tools for analysis due to the possibility of simultaneously providing both purely quantitative data and their three-dimensional spatialisation. The latter property is essential as it is of great help in the critical interpretation of purely numerical data.
The user's possibility to build customised algorithms, capable of equally effectively working at different scales, ensures a high degree of control over the entire analysis process, from the simulation of the environment to the extraction of the data to be analysed, up to the production of the results and their representation.
The proposed algorithms can be further implemented in different directions: the introduction of components that allow for the processing of other types of data, such as LiDAR data, at both territorial and urban scales; the application of filters that model human vision more accurately, for example by introducing a maximum radius of analysis from the chosen viewpoint; segmentation tools that allow for more specific analyses.

Notes

1. The Department of Architecture of the Roma Tre University has been researching cultural landscapes for many years; the research on Manziana was developed between 2016 and 2020 within a framework agreement with the Municipality of Manziana coordinated by Prof. Giovanna Spadafora (Drawing) and Prof. Saverio Sturm (History of Architecture). Thanks to this convention, two research grants were activated in 2016 and 2018, the second one being co-financed by the Municipality of Manziana.

2. Conti 1980.

3. Bruschi 2000.

4. Rinaldi 1978.

5. Sturm 2014; Colonna 2016.

6. Wasserman 1966; Marconi 1974.

7. Mancini 2017; Mancini 2019.

8. Rizzo 1990.

9. Norberg-Schulz 2016.

10. Norberg-Schulz 2012.

11. Mancini 2020.

12. Norberg-Schulz 2016.

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Her researches are focused on the field of Representation of Architecture and Digital Survey.

12 THROUGHOUT HISTORY AND IMAGES: FOR A DIGITAL INTERPRETATION OF A LATE RENAISSANCE CYCLE OF FRESCOES

GIULIA PICCININ

Abstract

The proposed study is the result of a research project carried out in different steps with the collaboration of research fellows belonging to two universities, Università Iuav di Venezia and Università degli Studi di Padova[1].

The research is focused on the analysis of the Sixteenth-century fresco which decorates the site of the Scuola del Carmine in Padua. The seventeen scenes composing it have been the focus of the study carried out by: data acquisition by digital survey integrated with historical researches; tracing an interoperable database containing documentation and hypothesis; integration between 3D models related to the frescoes and to the architecture with data gathered from the database.

The analysis carried out enabled the creation of multimedia systems able to allow the navigation and questioning of the semantic model.

Lo studio che si propone è il risultato del progetto di ricerca portato avanti in più fasi con la collaborazione di ricercatori afferenti ai due atenei veneti, l'Università Iuav di Venezia e l'Università degli Studi di Padova[1].

La ricerca è incentrata sull'analisi del ciclo pittorico cinquecentesco che decora la sede della Scuola del Carmine di Padova. Le diciassette scene che lo costituiscono sono state oggetto di analisi, effettuata mediante: acquisizioni dei dati attraverso operazioni di rilievo digitale integrato alle ricerche documentali storiche; tracciamento di un database interoperabile contenente documentazioni e interpretazioni; integrazione dei modelli 3D relativi alle quadrature e all'architettura con dati provenienti dal database. L'analisi condotta ha consentito la creazione di strumenti multimediali in grado di permettere la navigazione e l'interrogazione del modello semantico.

The so-called 'Scuola del Carmine' is one of the oldest *Scuole*, or *Fraglie*, of the city of Padua. These institutions are confraternities of citizens, firstly arose in Venice during the Middle Ages than widespread in the surroundings; they arose as charitable and religious organizations in which people could offer help, work and assistance to the confreres. Nowadays they are still in function even if with different aims; they have always had their own hierarchy but, above all, they have their sites as representative buildings. Then, their popularity and power have grown specially during the Renaissance, when the *Scuole* became very rich and started decorating their buildings with works by important artists, so that nowadays, is very frequent to use the term '*Scuola*' referring to the site more than to the confraternity itself. This matter increasingly spread in the surroundings and, at the same way, the same process of diffusion grew even in Padua, where the confraternity of the Scuola del Carmine, the topic of this research, takes place nowadays.
The Scuola del Carmine has been founded by the religious order of the Carmelites.

Fig. 1 - View of the interior of the so-called Sala del Capitolo.

Fig. 2 - Orthogonal projections of the Scuola del Carmine and orthophotos of the frescoes. On the plan, from left to right, the entrance, the sacristy and the Sala del Capitolo.

The building is located in the north of the city, where the order of the Carmelites had been established since the Middle Ages, just beyond the borders of the ancient medieval walls of the city and close to the city gate of Porta di Ponte Molino. In detail, it is located in the square called Piazza Petrarca, from where it is possible to reach the entrance on the main facade of the building.
The essay is focused on a specific part of the research project, the one dedicated to the analysis of the cycle of frescoes painted on the walls of the main room of the *Scuola*, the so-called 'Sala del Capitolo' (fig. 1). Indeed, the main goal of the study consists in the development of multimedia systems able to allow users to visualize, understand and interpret the contents of each scene of the fresco, using immersive technologies and innovative devices in order to easily reach the contents gathered from the digital survey, from the geometrical analysis and from the historical research. Initially, it has been possible to 'read' the building and find out all the variations made over time on the fresco thanks to the information gathered from the

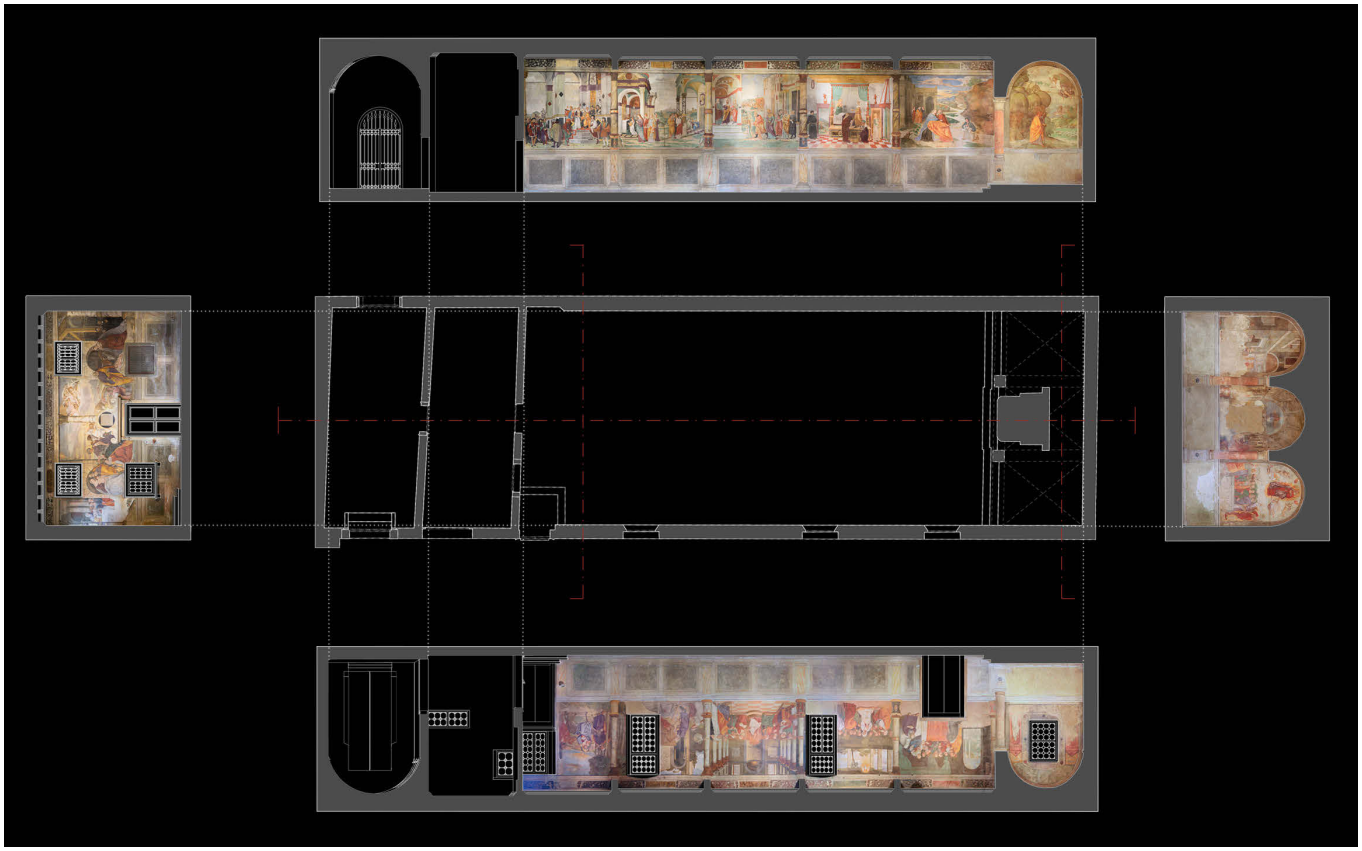

Fig. 3 - Frescoes on the walls of the sacristy; on the scenes it's still possible to see the columns made in 1492 to split the original fresco in parts.

digital survey: indeed, this step has been essential in order to know and describe the structure and the main features of the building and the frescoes; historical documents have been supported by the point cloud gathered by laser scanning technology and, in addition, supported also by data obtained from georadar and thermography, which highlighted discontinuity of materials underneath the surfaces of the frescoes.

Indeed, the entire area of the *Scuola*, which is divided into three spaces, the main entrance, the sacristy and the Sala del Capitolo (fig. 2), have gradually undergone many changes of function[2] but also structural alterations made over time: the humidity and temperature of the walls partially destroyed the original frescoes so that some parts have been lost and restored later; because of the necessity of creating a new space (nowadays the sacristy) between the entrance and the main room, a new wall has been built in the middle of the 16th century, modifying the composition of the original cycle of frescoes. In this way, some scenes of the narration have been left out, on the walls of the sacristy (fig. 3), but painted again on the new wall. Therefore, the frescoes of the Sala del Capitolo have been made in a long period of time, starting from 1492 to the end of the following century[3].

The case-study of the research consists of the seventeen scenes still visible in the Sala del Capitolo, which are made following precise geometric processes for perspective construction. More in detail, the fresco is made by three main elements: a basement with columns, equally painted using perspective (still visible also on the previous frescoes set on the walls of the sacristy), the scenes of the frescoes and the frieze (fig. 4). The basement and the columns are

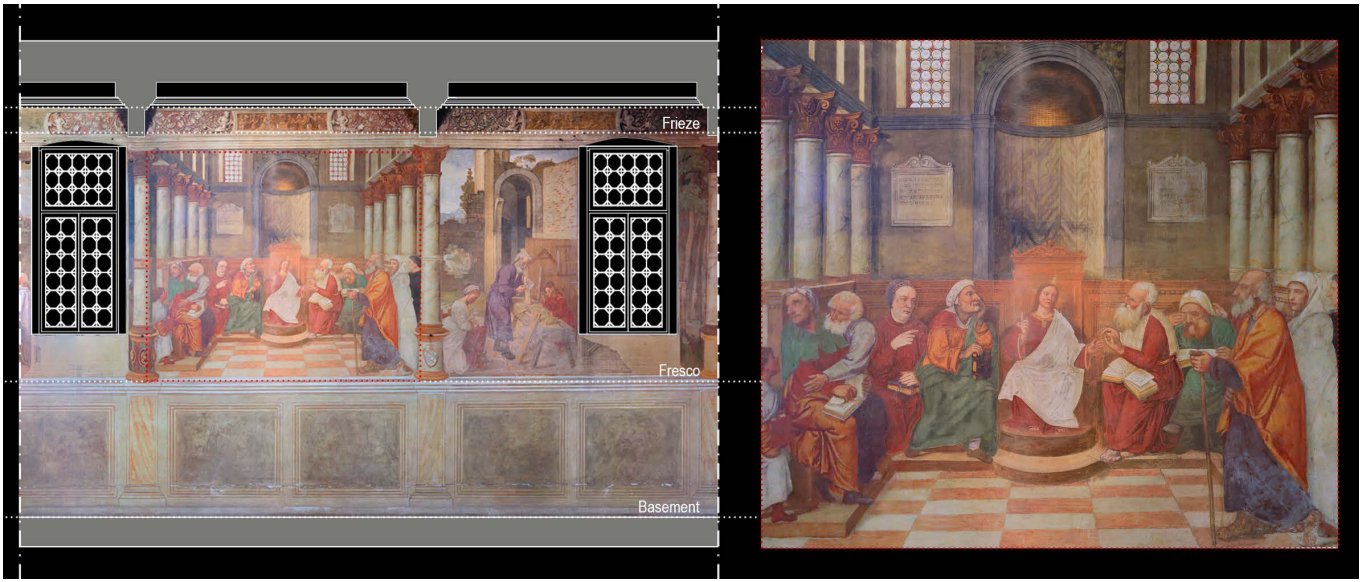

Fig. 4 - On the left: section of the Sala del Capitolo and individuation of the main elements of the composition. On the right: the fresco Jesus and the Doctors of the Church (1533) painted by Girolamo del Santo, highlighted as an example of the geometrical analysis.

the first elements painted in 1492; this system, made to split the surfaces of the walls into seventeen parts, has an important role in the connection between built and painted space because, inside the virtual space, this is the filter that allows to switch from the built structure to the paintings. The photogrammetry applied during the digital survey campaign has been useful to obtain orthographic views of the scenes in order to apply the geometrical process known as inverse perspective rectification to the scenes represented in the cycle of frescoes. This step has been useful also to understand the constructive phases that guided the digital reconstruction of the paintings and provided the data needed to create the digital models of the spaces painted in the frescoed scenes: these are composed by architectures and views of the city of Padua, on the background of the biblical narration. As they are painted using perspective, the geometrical analysis of the scenes allowed to recognize firstly the geometrical reference system of the perspective, detecting the position of the ideal observer by applying inverse geometrical process (fig. 5).

The geometrical research follows precise steps: once the ground line has been set at a height of 182 cm from the actual floor[4] (fig. 6), the position of the ideal observer is found thanks to the vanishing point of the straight lines orthogonal to the picture plane, the distance circle and the distance points, which were identified taking into account some geometrical elements depicted in the fresco as squares and circles (geometries that define the shape of some architectural details inside the scene)[5]. Consequently, it has been possible to obtain plans and sections of the painted architecture, which have been useful to the following 3D reconstruction (fig. 7).

The digital models of the painted space allowed to highlight features of the composition of the painted spaces and to achieve an interpretation on adjustments and strategies applied by the artists for the execution of the art works. Therefore, after the first phase of 'decomposition' and analysis of the fresco, it has been possible to assign the position of the virtual observer, according to the informations previously gathered during the geometrical analysis. Though, it has been possible to apply the process to all the frescoes including architectures and interior spaces: open spaces, as countrysides or hills and rivers, without the presence of geometrical objects, are not appropriate for the inverse perspective process.
Therefore, all datas obtained by historical documents, digital survey and geometrical analysis have been essential as a base for the creation of the digital models, which simultaneously define, through BIM modeling, the built architecture and, through NURBS modeling, the painted space of the frescoes; a uniform virtual space allowed to join the two realities into the same typology of matter,

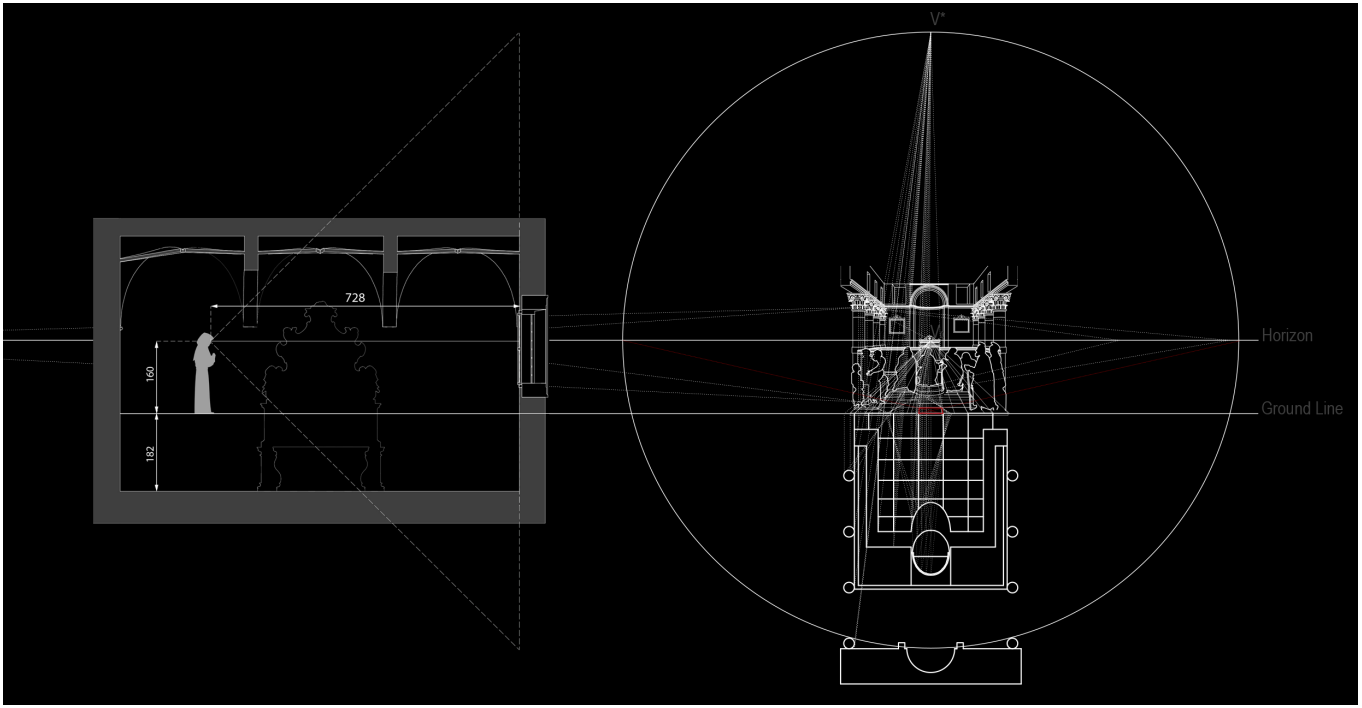

Fig. 5 - Geometrical analysis of the scenes; on the left: the position of the observer in section; on the right: homological operations applied to obtain plan and sections of the painted space.

Fig. 6 - 3D model of the basement and columns which create the filter between the built architecture and the frescoes, with the graphic of the reference system of the perspective.


V*
D1
V0
D2

in order to benefit from their spatial interaction, which is generally possible only thanks to the visual process of the actual user on site. The 3D modeling procedure becomes the crucial instrument to merge the two kinds of identities, originally materialized by different physical supports. In particular, the BIM model contains both the architecture of the *Scuola*, as built, and the painted architectures of the frescoes; the unique virtual space keeps together the two parts, as they were made of the same matter.
Moreover, the BIM model is enriched with historical informations of the building regarding variations and events that affected the structure and its contents, even the frescoes. The timeline is split in four different historical phases in which are explained the architectural changes that modified the structure and features of the cycle of frescoes. So, the conservation of the frescoes is strictly linked to the control and the maintenance of the structure which is their physical support. Then, immersive technologies grant the possibility to visualize the digital space and obtain informations from the 3D models for a double goal: the one related to the maintenance of the structure (more focused on the management of the institution, handled by technicians and operators) and the one related to the use by guests and tourists, in terms of digital museum.
Taking into account the possibilities of the institution itself, Augmented Reality and Virtual Reality applied to the digital models have been experimented using different kinds of devices, nowadays available in commerce.
With the aim of finding out the best instrument to experience the virtual space, the digital models have been imported in an immersive room, in an head-mounted display and in a web VR platform and modified according to the features of each device. All of these indeed let different kinds of visualization, so that it has been necessary to organize the contents of the experience in a different way. The first one has been useful to interact, firstly, with the point cloud gathered from the digital survey, then with the models of the *Scuola* together with the models of the frescoes; inside a 3 x 3 x 3 meters room, thanks to the use of a controller, the user has the possibility to handle the contents choosing his/her own virtual tour and visualize and experience them as a surrounding environment with texts, drawings and pictures able to explain all the elements and features that characterize the *Scuola*, both as built or painted, or its painted and sculptural art works. This result has been reached by organizing different scenes so that the final user may be facilitated in changing historical phases (fig. 8), in which the evolution of the construction of the structure is divided, or in moving inside the painted space of the frescoes: virtually entering the architectures in the frescoes allows to virtually extend the physical boundaries of the *Scuola* crossing the painted colonnade that scan the subdivision of the fresco in scenes, working as a filter between the two different kind of matter in which the whole space is made. In this passage, the user is virtually replaced on a new ideal floor, the one that characterizes the perspective views of the frescoes, set 182 cm higher than the actual floor, which allows to enter inside the painted space and be part of the scene.
Subsequently, Virtual Reality has been tested using an head-mounted display, based on a guided tour, which is made of a series of preset videos, in order to reduce the timing of the visit but isolating the user from the physical environment which surrounds him/her. The guided tour includes also texts, images and specific informations that explain in detail the features of each element that appears during the virtual visit.
At the end, the contents have been assembled on a Web VR platform which the user can employ using a common laptop in remote control; the system is made of a series of commands that is possible to activate from the keyboard, with no limits of time, no physical boundaries and without being on the site. In this way it is possible to achieve informations as texts, images, videos, audio files interacting directly with the elements of which the 3D model is made.

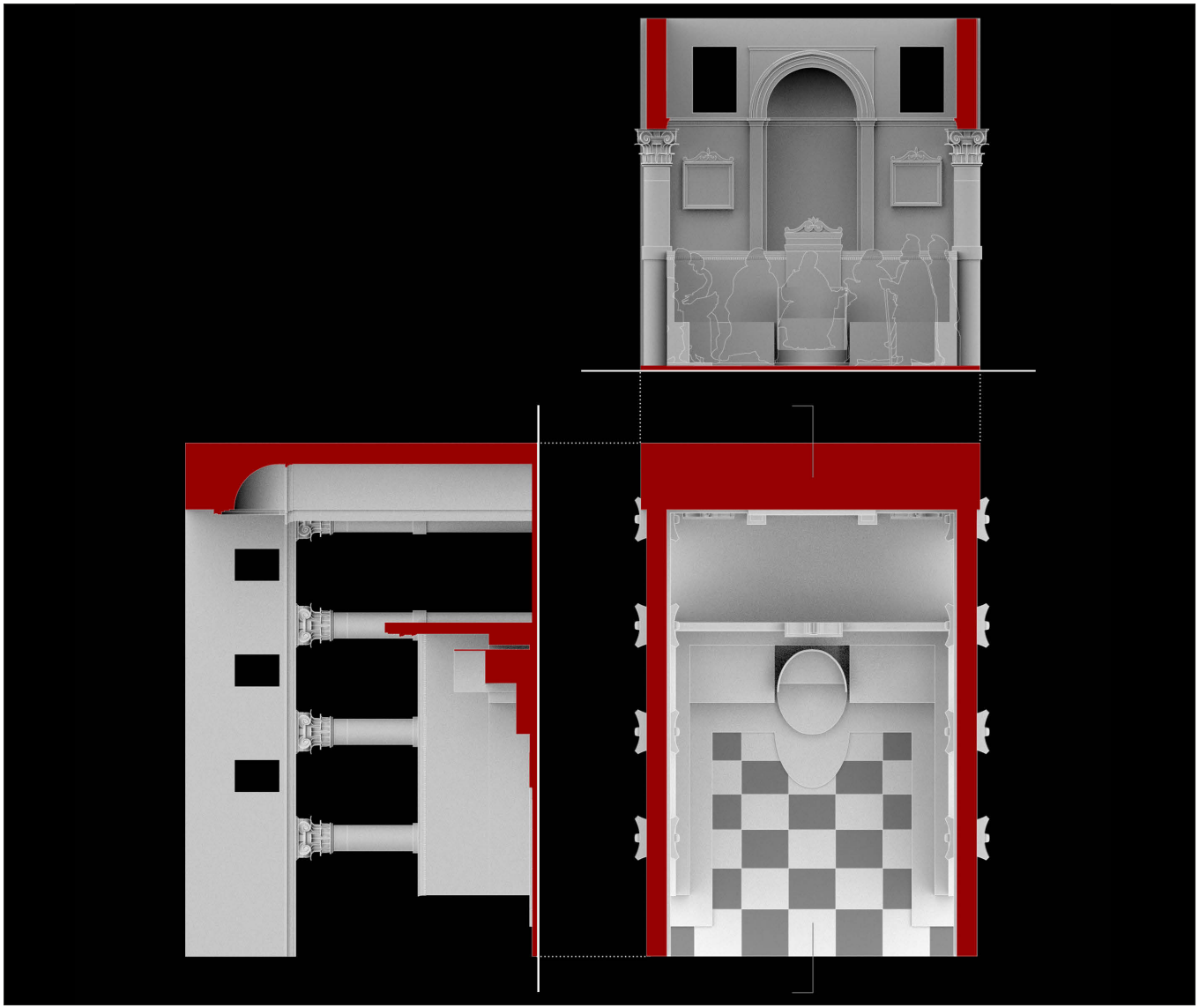

Fig. 7 - Plan and sections of the frescoed architecture obtained from the geometrical analysis.

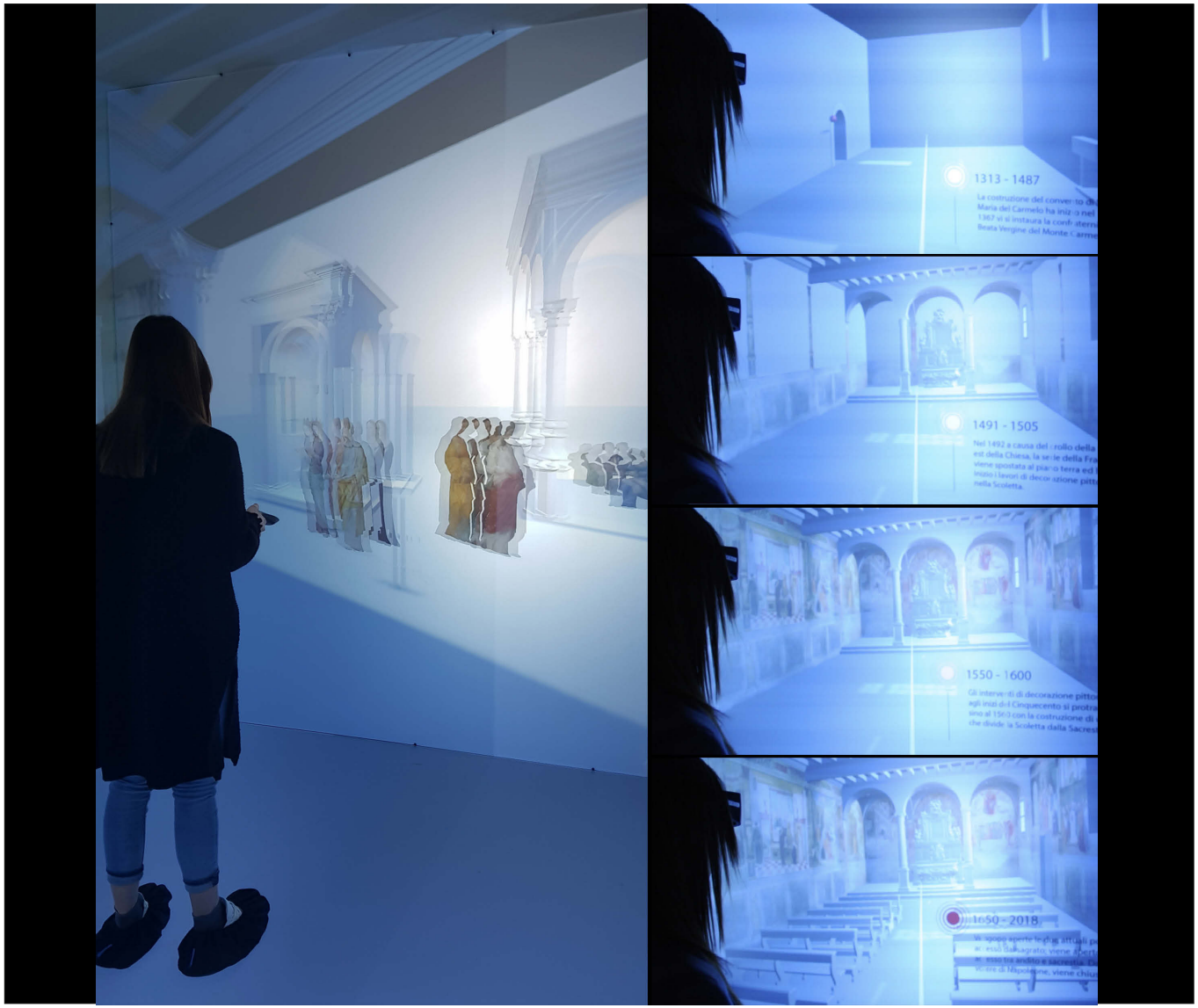

Fig. 8 - 3D models of the Scuola and of the frescoes inside the immersive room Cave (Duke University of North Carolina, USA); on the right, the historical construction phases of the building enabled by the user.

Moreover, Augmented Reality gave the possibility to add extra contents related to the frescoes coming from a critic analysis of the scenes with the aim to offer a more detailed visit to the users: related to the frescoes, a specific App has been developed for smartphone and tablet, able to summarize the contents and let the visitor obtain them using his/her own device, integrating the on site visit with the necessary informations. Scanning a QR code it is possible to obtain informations keeping the framing on the fresco enjoying a guided visit of the *Scuola*. The App is filled with interactive contents becoming from the analysis of different topics, in particular related to: the biblical narration of the fresco; the biographies of the artists involved in the project; the geographical references of the painted backgrounds, identified in the actual city of Padua and in the surroundings, to which pictures of the same places are added for a comparison between the real view and the painted one; the geometric and perspective analysis, explained using drawings and graphic schemes.

The analysis carried out with the project, which is always updated with new informations, allows some considerations on the use of technologies applied to the historical heritage, which is effective for this specific case-study but could be extended to more general circumstances.

The contents organized in Apps require a new approach by the user for the visit of the digital museum: the user could experience a more dynamic and active kind of visit, based on the control of it, thanks to a self-decision to gather the informations, which are due to his/her interests, through his/her own device (laptop, smartphone or tablet). The diffusion and the friendliness in the use of these devices allowed the digital visualization in our everyday life so that the level of expectation is always higher: the visualization through immersive technologies is very similar to the real environment of everyday life. This allows a more comprehensible experience for the users. More in general, immersive technologies can offer to exceed structural and physical boundaries: it is possible to go beyond the material limits of the building and browse a uniform space, which is immaterial, unlimited and accessible; there are no geographical constrains: thanks to real-time visualization, it is possible to discover the geographical areas as landscapes shown in the frescoes; but also it is possible to have a tour of the building, directly using a laptop so that is not necessary to be on site. The process made so far gives the possibility to have an interactive media system to browse the information and the user is involved to customize his/her personal tour: he/she has an important and active role in the visit. The comprehension and the interpretation of the contents, made possible thanks to virtual clones and accessible through a personal device, is always closer to the phenomenal experience of everyday life.

The research, in detail, tried to demonstrate how historical architecture can be linked to new technologies in 3D visualization and be emphasized using Virtual Reality and Augmented Reality, keeping together data made from different kind of support and sources, from historical document to precise reconstruction with interoperable virtual models.

Notes

1. The case-study of the Scuola del Carmine in Padua has been analyzed in the project titled *MONADII/Metodologie per l'acquisizione, l'elaborazione e la comunicazione di dati relativi ai beni culturali e per il progetto architettonico e tecnologico di interventi atti alla loro conservazione e al miglioramento della fruizione turistico-culturale,* cofounded by Fondo Sociale Europeo (FSE), Scientific Coordinator prof. Cosimo Monteleone. This research involved, as research fellows, Rachele Angela Bernardello, Mirka Dalla Longa, Emanuela Faresin from Università degli studi di Padova and Isabella Friso and Giulia Piccinin from Università Iuav di Venezia.

2. The Sala del Capitolo was anciently the refectory of the order of the Carmelites.

3. The main cycle of frescoes is made by the seventeen scenes, painted from 1505 to 1560. The artists of the frescoes, in order of execution are: Giulio Campagnola, Domenico Campagnola, Girolamo del Santo and Stefano dall'Arzere [Gasparotto 1955].

4. The ground line is set on the edge between the scenes of the cycle of frescoes and the basement; this means that the geometric scheme behind the scenes has been defined by the artists without considering the final position of the fresco inside the built architecture. It is necessary to keep in mind this feature while navigating inside the digital models: this entails adding an additional virtual floor inside the digital model where the virtual user can walk on.

5. Sgrosso 1979.

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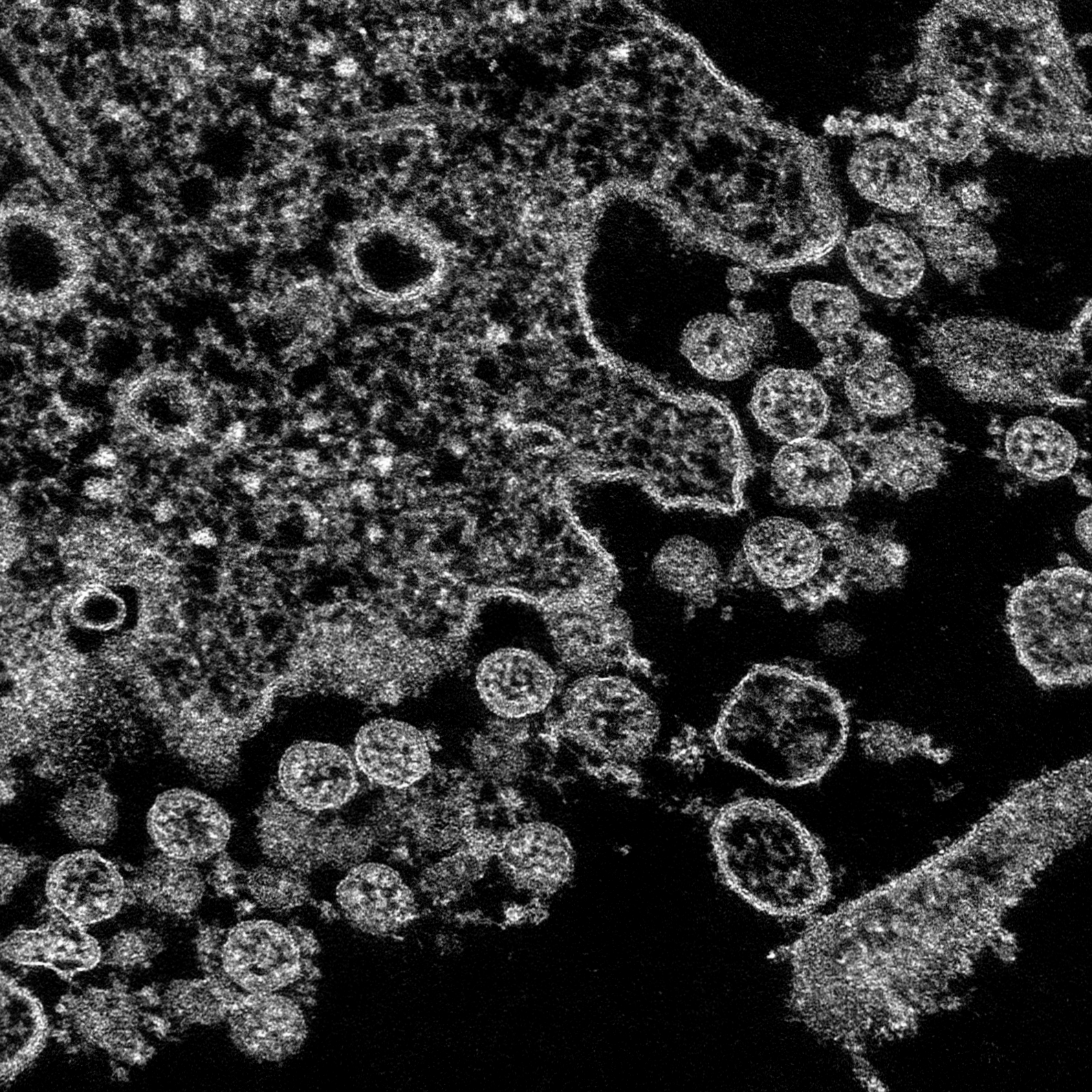

PANEL DISCUSSION

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AFTERWORD

The conference, in its third edition, gave countless elements for reflection on the potentiality of digitization, management, documentation and enhancement of museums and museum's collections.
During the round table, that had as protagonists the researchers Massimiliano Ciammaichella, Alessandra Cirafici and Marco Fasolo as well as Laura Inzerillo and Cettina Santagati, interesting considerations emerged in relation to drawing and its semantic aspects and concerning the model as a means of communication.
The level of the contributions of each session has been higher than the expectations and the keynote presentations have been excellent. Augmented Reality, Virtual Reality, 3D animated modelling, H-BIM, Reverse Engineering, ortophotos, TLS and SfM procedures and so on, are the main fields of investigation that made as landscape to the conference.
Massimiliano Ciammaichella focused on the semantic path of the presentations highlighting the importance of historical knowledge that guides the research work in drawn digital reconstructions of fragments, or of entire architectural buildings, making them coexist with the real spaces that once housed them. The focus has been shifted to the museum and the pandemic difficulties. In particular, the multimedia itinerary, which guides visitors, uses video mapping in virtual resstoration strategies that make reproductions of the ancient decorative skins, which have been lost, appear on the walls, and light becomes the leitmotif of the entire exhibition. Following all the presentations, Ciammaichella achieved the conclusion that drawing is a discipline in constant updating, achieving a pivotal role in the management and enhancement of the Artistic and Cultural Heritage.
Alessandra Cirafici focused her attention on the role played by the new digital paradigm in the definitive transition from the idea of a museum as a collection of items to the idea of a museum as a 'narrative' path to live a cultural experience. According to Cirafici, the fruition of Cultural Heritage can be considered as a hybrid system in terms of visual languages and communication strategies. Places in which material and immaterial, reality and virtuality coexist, overlap and mix.
Cirafici expressed her concerns related to the possibility to lose the human relation between the 'mediator' and the visitor. The automation due to the Virtual and Augmented Reality could admit the risk that a substantial 'disintermediation' of the cultural experience is possible. At the end, Cirafici gives us a challenge: to achieve "the ability to intercept the new elements of this story, to tell the story of cultural heritage according to logics and methods in which reality does not stop exerting its irresistible charm, but the virtual dimension amplifies its meaning, weaving together with it narratives of unprecedented expressive power, as the recent experience of the pandemic has shown us and on which we need to continue to reflect."

Marco Fasolo follows the path of presentations too and concludes his contribution, aimed at exalting the quality of the research and the scientific methodology, as well as highlighting the passion of the scholars who presented their works, with a famous sentence by Karl Popper: "What matters is not methods or techniques but a sensitivity to problems, and a consuming passion for them, or, as the Greeks said, the gift of wonder".
As in the previous editions, the *Digital&Documentation* Conference gave to young researchers the opportunity to present their works, illustrating their reasoning and methodologies to a broad public; in the meantime, all the presentations gave to the audience an up to date state of the art on the latest discovers and methodologies, as well as future perspectives on novel research direction on this relevant topic.

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Massimiliano Ciammaichella

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Massimiliano Ciammaichella (July 12, 1973), Architect, Ph.D., Assistant Professor and Associate Professor in Drawing since 2014, was founding partner of New Design Vision (2017-2019), Spin off of the Università Iuav di Venezia. In the same University he has been director of the master's degree programme in *Science and Techniques of Theatre* (2016-2018). He has been continuously involved in research since the beginning of his career, both by collaborating in national research projects funded through calls for proposals (PRIN), and international (INTERREG), participating in University calls for funding of research activities, and independently, spending some periods of study abroad. The scientific path can be traced back to the field of Drawing, with a strong orientation towards the innovation of methods and tools for the representation of architecture, product and communication design, fashion design, visual and performing arts.

CULTURAL HERITAGE.
DECLINATION AND DRAWING OF THE EXPERIENCE

The Conference third edition focused on the study, protection, valorisation, and promotion of cultural heritage, recording a great versatility of approach in dealing with extremely competent research topics whose results have been presented and discussed by the protagonists: Ph.D.students and Ph.D.researchers of the drawing discipline.
The common trait of all the experiences is marked by experimentation with advanced digital technologies that invest in the representation, ranging from the artefacts survey to the reconstruction of three-dimensional models of tangible and intangible memories that are confronted with real narratives able to evoking their essence within the exhibition contexts.
The introductory contributions reflect on the specific meanings of the role that cultural heritage plays at the European level today, in being interpreted in a holistic and integrated way, which sees the active individuals in enjoying it and in giving it a value – because it is open to wider communities –, so the democratic principle of participation also becomes the collaborative expedient to preserve it and return it to future generations.
Hence the need to stimulate a collective intelligence, according to which the declinations of the heritage term become opportunities for dialogue and comparison, in the cultural identities' manifestation entrenched in the changing history of the territories in which they are positioned, opening the frontiers of their accessibility to anyone [Sciacchitano].
This principle can only be extended to the institutional venues of museums, where digital technologies applied to cultural heritage take into account conservation aimed at the documentation for archival and diagnostic purposes, for management, protection and access to knowledge, but are also excellent communication tools to be involved in the processes of reading and coding of works, facilitating their understanding by a heterogeneous audience [Russo, Rinaldi].
According to that logic, historical knowledge guides the research work in the drawn digital reconstructions of fragments, or entire architectural bodies, making them coexist with the real spaces that once housed them, as can be seen in the interventions that in recent years have involved the Colosseum's Archaeological Park in Rome. In particular, the multimedia itinerary, which guides visitors through Nero's Domus Aurea, uses video mapping in virtual restoration strategies that make reproductions of the ancient decorative skins, which have been lost, appear on the walls, and light becomes the leitmotif of the entire exhibition [Borghini].
As we know, the current pandemic condition has forced museums to close or open for intermittent periods, limiting the number of visitors. Although the planned timing of exhibitions has been respected, museum institutions have been forced to reflect on their communication strategies, opening as much as possible to the popular channels of web and social networks [Aureli].

In view of inclusiveness aimed at facilitating access to knowledge, circumscribed by the exhibition contexts, the research present case studies that question the ways in which the content can be used, in a direct dialogue between the tangible presence and its computerized digital cloning, which is entrusted with the task of describing it.
In the case of painted architecture, for example, the frescoes in the Capitolo room of the Scuola del Carmine in Padua have been surveyed to get perspective restitutions and three-dimensional reconstructions, starting with high-resolution orthophotos to integrate the results obtained into virtual and augmented reality devices that allow visitors to interact directly with the works, including through the usual smartphones and tablets [Piccinin].
The Gorizia ConTatto project is dedicated to an audience of blind and visually impaired people, where 3D printed reproductions of architecture and sculptural models coexist with tactile maps to guide the visually impaired and the blind in an exhibition where learning is entrusted to direct contact between hands and the reproductions of works [Riavis, Cochelli].
On the techniques of digital prototyping, dedicated to the musealization of artifacts, mainly aimed at student training, is addressed the deepening of the application interconnections between mathematics and architecture through descriptive geometry, to enhance the collection of mathematical models contained in the Peano Library of Turin [Pavignano].
Great impact for the development of knowledge is the research results that resume the study of famous authors, artists and treatisers, in tracing the direct connections between theories, methods and design approaches that confronting them with the real places of experience.
For example, the activity of Leonardo da Vinci, as a military architect operating in Piombino in the early sixteenth century, is investigated starting from a careful analysis of the historical sources and drawings contained in the manuscripts, to re-read the transformations that over the centuries have affected the urban fabric of the fortified city, in which it has operated with survey campaigns that use the potential of digital photogrammetry and 3D laser scanning [Bigongiari]. The same technologies are used in the deepening of the obliquazioni proposed by Juan Caramuel de Lobkowitz, in the case of the Vigevano cathedral façade [Gasperuzzo].
On the stereotomic apparatus of the cylindrical vaults, offered by Guarino Guarini, instead, the scripts of the Visual Programming Language are applied, in a dynamic visual translation of the geometric fundaments described in the third chapter of the fourth treatise of L'Architettura civile [Borin].
The richness of the proposed themes is compared with the updating of a technological complex, not strictly focused on the single instrument, if anything, on the ultimate goal of the achieved result that continues to evolve the meaning of the model transforming it into a computerized memory archive, interoperable and interrogatable through specific taxonomies [Quattrini].

The H-BIM applications extend from the chronological transformative evolution of individual architectures [Porfiri] to entire territory portions, dealing with huge amounts of data to be re-semantize and brought back into usable protocols, in the management of a census database for the valorisation of cultural routes [De Marco, Dell'Amico]. In other cases, the development of data integration methodologies raises questions about the criteria for defining usage protocols, to build a common and shared vocabulary for open access to information [Cera].
Hierarchical classification of data simplifies the representation and interpretation of numerical models of architectures, whose structural elements are segmented into abacuses to be interpolated with machine learning algorithms [Grilli]. In other cases, the Visual Programming Language, VPL, is very effective in managing H-BIM platforms that integrate parametric models of monumental architectures [Calvano, Calcerano, Martinelli, Gigliarelli], or they are very suitable for the analysis of urban transformations of an entire landscape [Mancini].
From all this it is understood how drawing is a discipline in constant updating, taking on a central role in the management of the artistic and cultural heritage. We have seen how digital technologies powerful means at the service of the expert drawing researcher are, who uses them freely, both in the documentation and communication processes, and in performing exhibition strategies, but they are also aids to experiment with new forms of expressive language when you measure with your own subjective manifestation of a poetic visionary [Farinella, Greco].

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FROM 'ABSTRACT VALUE' TO 'SHARED VALUE'. TRAVEL NOTES

During that intense day of discussion and reflection, I took many notes! Summarising them today in a few brief coments is not easy. Participation, accessibility and sharing are still, in all likelihood, the words that best describe the discussions of that day, but there is no doubt that some elements of that intense debate, more than others, have found resonance in the condition experienced in recent months, in which social distance and digital technologies have formed an inseparable combination. Two elements that have ended up orienting an overall rethinking on how the theme of distance has forced a large number of social, cultural, working and educational practices to a significant digital re-mediation. In the last few months we have all experienced an unprecedented concept of 'proximity', which became even more intense when we were forced to decline it in the specific field of the 'denied' experience of museum fruition. It was a matter of extending and specifying in the condition of the present time, a theme that, as we know, is already central to the contemporary debate around strategies of valorisation and audience development through digital. It is, in a broad sense, the area of reflection related to the role that new technologies can play in the significant changes that characterise the universe of cultural experience today. More specifically, it concerns the role played by the new digital paradigm in the definitive transition from the idea of a museum as a collection to the idea of a museum as a 'narrative' or, if we were to take up the words that resounded several times during the conference last December, it is the transition from the idea of the museum as a 'temple' to that of the museum as a 'forum' . A shift that is not only semantic, in which we can essentially see the significant transformation in the way of understanding the role of the user in the cultural experience and which forces us to reflect on the ways of this new attitude, which we tend to define as that of prosumer.

In little more than a decade, almost everything has changed in the field of the fruition of cultural heritage, and the scenario we have before us today proposes a vision of exhibition sites - in the broadest sense that the term can be used - as 'complex devices', in a certain sense hybrid in terms of visual languages and communication strategies. Places in which material and immaterial coexist, overlap and mix. A meaning of cultural fruition in which the experience of the pandemic and the 'social distancing' that was the inevitable consequence, have triggered a sudden acceleration and indicated new interpretative paths for some of the issues that have always characterised the debate on the relationship between culture and digital. For some time now, we have been wondering about the role that digital technologies can play in strengthening the value of the relationship between the work and the user, which is a crucial element in generating a society that is truly oriented towards the production of culture. We have been wondering about the way in which new technologies are able to respond effectively to the ever-increasing demand to experiment with new forms of access to knowledge, overcoming the limits of physical presence and inaugurating new virtual and immersive spaces. Today, however, there is perhaps an urgent need to question the way in which the new digital technologies have questioned the need for 'human mediation' in the transfer of

cultural experience, almost suggesting the possibility that it can totally do without the function of a mediator, (a guide, a teacher, a curator, a director), a narrator, in short, in flesh and blood with whom to interact, thus ending by enunciating the risky principle according to which a substantial 'disintermediation' of the cultural experience is possible.
The fact is that technology in itself remains an abstract factor if it is not culturally 're-elaborated'; in other words, if it is not able to return to society outcomes that truly respond to the changing needs and requirements of the community. After all, the most significant change taking place in cultural policies derives precisely from the new notion of 'accessibility to information', as it is interpreted in the context of the knowledge society. What is evident today is the need to respond not so much, or at least not only, 'technically', but creatively to the unexpected and ever-growing demand for experimentation with new forms of access to knowledge. The widespread entry of digital culture into museums, libraries, archives, etc., the new 'rhetoric' of access to data has opened up unexpected spaces for mental processing and in some ways justified a radical change of perspective, inverting the roles between the reasons of conservation and protection and those, now prevalent, of exploitation, use and communication. What is required of exhibition sites is that they increasingly play the role of true 'narrative habitats', places where the exhibition dimension is far surpassed by personal experience, interaction and emotional involvement. Places in which memory becomes a story, in which the idea of a 'visit' is transformed into active participation in a cultural event, in a performance.
This way of understanding the relationship with the work of art encapsulates the fundamental transformation of cultural fruition from a 'spectatorial' function to a 'participatory' function, and sees the user as the central figure in the process, in a dialectic that is essentially expressed through the universe of his or her emotions. This is a scenario in which digital technology can play a fundamental role in the development of new participatory models, increasingly oriented towards the inclusion of the community in the process of interpreting cultural heritage, and which are based on 'narration' as a communicative and cognitive tool capable of recalling experiences, bringing them to life through the attribution of meanings associated with the facts narrated, contributing to the generation of a common sense through the social sharing of the story, using emotional and immersive strategies, capable of giving rise to a process of identification with the object of the story. The 'narrative voice' can and must be able to modulate the narrative, identify levels of interpretation, and build new narrative paths dedicated to the users in front of it, whether they are a public accustomed to the museum experience, to be intrigued by new points of view, or a neophyte in whom the pleasure of beauty and culture can be triggered. The theme becomes particularly interesting if we imagine to 'narrate' research paths in the museum, transforming the itinerary of research into an itinerary of community growth. In the new meaning of 'forum museums', they are more and more imagined as centres of scientific research 'without walls', where the experience starts before reaching the physical place of the

exhibition and is perpetuated afterwards, sometimes even transcending it; where the visitor is stimulated through several levels and several channels of interpretation. In this context, practices related to trans-medial narration are particularly effective when applied to the field of museum education and to the narration of research paths, even complex from a scientific and operational point of view, which are the heart of a museum’s life, its very reason for existing. The self-referential idea of research holed up in closed laboratories, inaccessible in a physical and metaphorical sense, incomprehensible to most people, has been replaced by an idea of research that is narrated not only at the moment of its representation in an exhibition, but also in its very happening as a spectacle and wonder of discovery, activating processes of awareness that often stimulate actions of collective participation. In this way, the two often distinct areas of scientific research and scientific dissemination can reinforce each other, contributing to defining the mission of a museum and its ability to dialogue with its heritage and the public.

After all, the history of a cultural heritage has always been built on the dialogue it has been able to establish with its users over time. The value of a cultural heritage can be measured on the strength of this relationship, because it is a shared value around which intellectual development is created and a collective identity is defined. The challenges we face today, as researchers, educators and institutions in charge of protection and enhancement, concern precisely the ability to intercept the new elements of this story, to tell the story of cultural heritage according to logics and methods in which reality does not stop exerting its irresistible charm, but the virtual dimension amplifies its meaning, weaving together with it narratives of unprecedented expressive power, as the recent experience of the pandemic has shown us and on which we need to continue to reflect.

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He mainly devotes himself to studies on Descriptive geometry and related disciplines, paying particular attention to the relationships existing between the disciplines of Descriptive geometry, Representation and Architectural Survey. His scientific interests focus mainly on geometric studies without neglecting the historical aspects of representation and he deals with architectural survey experiences.

He is Coordinator of the Research Unit *Descriptive geometry and its applications* located at the Department of History, Representation and Restoration of Architecture and set up with the aim of promoting the renewal of the studies, the research and the teaching of Descriptive geometry and its applications.

A MODEL FOR READING AND COMMUNICATING CULTURAL HERITAGE

The Study Day we attended was rich in points that merit greater investigation than the space allowed, so I would like to summarize those that I think may have best characterized this interesting meeting.
First of all, I would start with the subtitle of the event: Understanding and Communicating the Cultural Heritage. As it was appropriately underlined by Orazio Carpenzano, the two activities are closely related, but above all it is their sequentiality that should be respected – first understanding and then communication. It would seem banal, a reflection taken for granted, but this is not the case. Too many times we have seen events destined exclusively to communicating various activities, for example, the transmission of architectural and landscape projects or archaeological sites, that overlook the overriding phase of knowledge. Let me be clear: I have nothing against events that expressly declare their exclusive aim to communicate, leaving the knowledge phase to other subjects, equipped with adequate competencies, but I personally appreciate it more when competencies regarding both knowledge and communication are found in a single scholar who can clarify them at any time. In the D&D Study day, this attitude was expressed in all the talks I attended.
Another important aspect of this Study Day lay in the great variety of scholars that took turns giving talks.
From the director of the Colosseum Archaeological Park, Alfonsina Russo, to the Colosseum manager, Federica Rinaldi, to the technical office manager of the Palazzo Barberini Museum, Dario Aureli, to Erminia Sciacchitano of MiBACT, who I recall as a student already then a step ahead in the then-doctorate course in Surveying and Representation of Architecture and the Environment in my department, now the Department of History, Representation, and Restoration of Architecture. Former professionals who then moved into superintendency roles, such as Stefano Borghini, who uses light to lend a vivid feeling to the Domus Aurea, or professionals such as Lorena Greco and Cristian Farinella, who, while mainly dedicating their activities to computer graphics, have felt the need to acquire greater methodological awareness through the doctoral course in my department.
But these figures should be recalled by turning especially to Ph.D.graduates and students such that they can open a view to their future, not only in the academic world, but also in professional activities related to their skills. This is also true of national and foreign institutions that, as we have seen, are ready to receive stimuli and competencies right from our disciplinary field, such as governing structures that have always placed particular attention on relationships with universities. I recall, in fact, when I oversaw the Undergraduate Degree Course in Architectural Sciences at the Sapienza, fruitful encounters with stakeholders to listen to their expectations about the curricular education of our students.
I should say, however, that what most struck me about the Study Day was all the talks by doctoral students and graduates who presented their work with lively passion, skill, and enthusiasm, perfectly meshing with the focus of the conference. Focusing on models, the talks referred to various scales, for example, the physical geometric/mathematical models housed

at the Biblioteca Peano in the Department of Mathematics in Turin as presented by Matteo Pavignano, which, in addition to excellently fulfilling their function as models, can also be seen as true objects of Design. Or digital models on the urban and territorial scale created by Matteo Flavio Mancini to investigate the visual relationships referring to the city of Manziana in both its inhabited centre and the territory of Lazio where the town is located. In sum, a complete path was presented among various topics studied through models, bringing to mind the famous slogan by Ernesto Nathan Rogers, 'from the spoon to the town'.

With regard to models, it is worth reflecting on the variety and types of models that all presenters used, models that varied in all respects — graphical, physical, and digital — even though the Study Day was mainly dedicated to the latter. It is now certain that to concretize an idea or realize a biased replica of a real object, reference must be made to the continuous flow of information, knowledge from both the individual model and the interaction between different types of models. I maintain, however, as is now critical, to formalize an idea about knowledge or a concrete fact, directing our research studies towards a new and original model is necessary, a hybrid model capable of summarizing the peculiarities of the different models.

An important conceptualization and experimentation of this sort of hybrid model was proposed by the above-mentioned Farinella and Greco in their contribution Hugh Ferriss d2 The Metropolis of Tomorrow. As also underlined by Massimiliano Ciammaichella, to be able to reread and interpretively reconstruct Ferriss' work, one must hybridize analogue techniques with digital techniques.

Models, that is, intended in their broader sense, are posed as the essential basis for scientific research and whose conscious use were skilfully expressed by Carlo Felice Manara. 'Very often the construction or use of a model is indispensable for activating knowledge about a reality that is at first glance viewed as too complex to be understood in greater depth. And the construction of a model often allows the knowledge one thinks they possess to be verified, tested, and subjected to criticism under certain theories; in turn, the existence of a model stimulates the construction of a theory that leads to a deeper understanding of the reality being studied.'[1]

All of the above supports my decision to invite students in my Representation class in the first year of the Undergraduate Degree Course in Architectural Sciences to participate as listeners in the initiative, given the topics addressed, which are widely directed towards the area of Representation. Following the Study Day, I have had the opportunity to talk with them about their impressions about what they saw and felt, and interesting points for reflection have emerged. Above all, I noticed their surprise at having discovered such a variety of demonstrations of Representation that their minds were opened to ideas and developments for their architectural future still in the making.

Finally, I conclude by observing how not only were the interventions all characterized by a serious, clear methodology, they were also supported by passionate enthusiasm recalled in the words of Karl Popper: "What matters is not methods or techniques but a sensitivity to problems, and a consuming passion for them, or, as the Greeks said, the gift of wonder".[2]

Marco Fasolo

Notes

1. "*Molto spesso la costruzione o l'utilizzazione di un modello sono indispensabili per poter avviare la conoscenza di una realtà che ci si presenta a prima vista come troppo complessa per poter essere conosciuta più profondamente. E spesso anche la costruzione di un modello permette di verificare, di convalidare e di sottoporre a critica le conoscenze che si credono possedute in forza di certe teorie; ed a sua volta l'esistenza di un modello stimola la costruzione di una teoria che conduca ad un possesso più profondo della realtà che si sta indagando.*": Manara C.F. (2001). Il concetto di modello nella scienza. In *Nuova Secondaria*, n. 7, Anno XVIII, p. 80.

2. Popper K.R. (2002). *Conjectures and Refutations: The Growth of Scientific Knowledge*. London: Routledge, p. 95.

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Digital & Documentation is a Study day, a moment of scientific-cultural exchange and updating that has reached its third online edition with the online meeting organized in Rome. The main purpose of the initiative is to ensure an update of scientific innovations in the field of digital documentation of Cultural Heritage, aimed at its reading, preservation and enhancement.

The documentation of Cultural Heritage has assumed, today more than ever, a fundamental role in the collective global cultural horizon: more and more frequently we are witnessing the occurrence of natural and sometimes even man-made events, which undermine the preservation of cultural assets. Therefore, it is essential to update the documentation of Cultural Heritage, intended in its broadest meaning, which brings together tangible and intangible assets belonging to man-made and natural space.

The D&D meeting becomes the scene of debates, comparison and demonstration of innovations, refinements, testing, methodologies, experimentations relating to acquisition process, critical and semantic analysis, dissemination and divulgation of Cultural Heritage.