

Hertziana Studies
in Art History



BIBLIOTHECA HERTZIANA
MAX PLANCK INSTITUTE
FOR ART HISTORY

Visualizing Complexities

Practices and Heuristics of Digital Models in Art History

Edited by Nicola Camerlenghi, Tanja Michalsky & Elisabetta Scirocco



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All articles of the present volume have undergone an anonymous scholarly peer-review by international experts to whom we are grateful for their generous support.

Graphic Project

Sergio Polano (2019)

Michele Elia (2023)

Page Layout

Michela Maguolo

ISBN | 978-3-949381-01-0

DOI | <https://doi.org/10.48431/hsah.02>

Published online on 31 October 2023

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Cover image: Rome, San Paolo fuori le mura, main altar, ca. 1823.
Reconstruction by Nicola Camerlenghi; 3D model by Evan Gallitelli;
image by Andrew Maurer.



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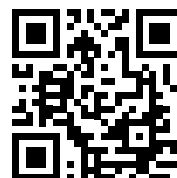
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Serious 3D in Art and Architectural History

Abstract

Tanja Michalsky, Nicola Camerlenghi
& Elisabetta Scirocco

Introduction

keywords – 3D Models, History of Art, History of
Architecture



Digital models help to visualize complexities heretofore unapproachable through more conventional methods of art history. The seductive qualities of these models—which tend to transcend those of words—are increasingly untempered by their digital and thus potentially alien nature. Modeling technologies—including, but not limited to, Gis, photogrammetry, laser scanning, vr, ar, or BIM—can assist not only in visualizing, but also in measuring, reconstructing and, thus, analyzing works of art and architecture. With the use of these tools come both challenges and opportunities. Furthermore, the interdisciplinarity of digital approaches invites diverse conventions, and as the media used for digital visualizations are adopted across disciplines and their hermeneutics contested, the resulting epistemes are naturally hybrid. This introduction presents the contributions contained in the volume and poses some of the most pressing questions about the process of visualizing artistic complexities.

DOI: <https://doi.org/10.48431/hsah.0201>

Introduction

*Tanja Michalsky
Nicola Camerlenghi
Elisabetta Scirocco*

These are exciting and promising times for scholars in the disciplines of Art History, Architectural History, Archaeology, and Heritage Conservation, who can choose to avail themselves of increasingly sophisticated digital models to expand their respective fields. The shared usage of digital models fosters new connections between these disciplines as well as with the field of Computer Science. The digital models that help scholars to visualize and analyze complexities heretofore inaccessible with more conventional approaches are the subject of this publication and of the conference from which it originated.¹

Specific modeling technologies include, but are not limited to, databases, digital maps, GIS, photogrammetry, laser scanning, virtual reality, augmented reality, architectural modeling, and Building Information Modeling (BIM and HBIM). Several, but not all these approaches are addressed in this volume. The emphasis is on three-dimensional, spatial models, which have benefitted from increasing sophistication. Much of their power derives from the intermediality they enable. To wit, a GIS project can collect and interpret not only points, lines, and polygons with geographic co-ordinates, but also a variety of textual or visual metadata associated with the mapped features. Similarly, a building scanned by photogrammetry and by laser can become a BIM model that carries all sorts of structured data used to justify the components of a model and to verify its scientific value. The variety of digital techniques used to generate models explains the challenges of achieving a common grammar and the lack of shared

conventions. Additionally, each modeling technology has its own set of demands regarding the model's afterlife, its interoperability, and re-usability. Perhaps the varying standards that we find in traditional publications, might serve as inspiration for scholars to recognize serious modeling work and learn to adjudicate variance in quality.

Why this turn to 3D models in our disciplines? Models can assist a scholar not only in visualizing, but also in plotting, organizing, reconstructing, measuring, and, therefore, analyzing a work. Of course, the same could be said for models in the sciences, but for the benefit of our argument we restrict ourselves to treating works of art and architecture. Particularly in the case of sculpture and architecture, given their inherent spatial nature, it is indispensable to do research and to think in 3D; indeed, one might feel obliged to explain and demonstrate such research in inherently spatial terms.

The use of more conventional media, such as fixed viewpoint drawings or even textual descriptions, to examine an object or space offers greater opportunities to leave uncertainties unaddressed. That which is unknown can remain undrawn or unwritten. In contrast, many of the 3D models addressed here (not only because they are interactive) "force" scholars to consider every possible aspect of an object or of a space. Moreover, they invite scholars to show as well as to test their hypotheses. This approach fosters a more holistic interpretation of the thing being studied than conventional media, behind which uncertainties can hide. All

¹ <https://www.biblhertz.it/3051429/visualizing-complexities-practices-and-heuristics-of-digital-models-in-art-history>.

told, interactive 3D models are a more demanding and powerful heuristic with which to tackle a work of art or architecture.

The practice of virtual anastylosis answers the need to (re)compose forms from fragments and fill lacunae, all the while balancing the desire for aesthetic appeal against scholarly demands for ‘unembellished’ truth. Given the allure of realism—particularly among a broader audience—it is crucial to devise digital models that disclose both fact and uncertainty, lest a proposal initiated as hypothetical become accepted as truth outside its original context or over the course of time. The seductive qualities of a virtual model—which tend to transcend those of words—are increasingly unhindered by technical shortcomings. Uncanny verisimilitude is achievable, if desired. But as more and more scholars adopt, develop, and apply this tool, challenges arise.

We must learn to harness 3D models to display levels of interpretative complexity and argumentation required of historic research. Because we live in a world where images are a principal vehicle by which we convey content, they are fetishized and ascribed inordinate power, instead of acknowledged for their ambivalence and ambiguity. We would do better to consider 3D models as a visualization of a hypothesis or idea. Along these lines, some scholars propose abandoning the term “reconstruction,” which is often synonymous with 3D models.² Some prefer the form “(re)construction” to signify “the theoretical nature of the research being undertaken, reinforcing the hypothetical nature of the models created.”³ Some others prefer to emphasize the hypothetical, interlocutory and provocative value of models as an invitation for discussion among equals.⁴ What is a model, but a creative synthesis based on interpretation and intuition? Indeed,

3D models are a scientific argument expressed through this specific medium. As with textual arguments or the drawings and plans often used by scholars, 3D models are based on research carried forth through specific methods.

Because, in our opinion, 3D models are explorative research tools and not the final aim, they deserve the same skepticism we apply to every scientific argument. This is an alternative to placing them on a pedestal on account of their seductive—and thus unquestioned—imagery. Without diminishing the importance of documentation and demonstrating the method for an argument, nor the fundamental importance of the findability, accessibility, interoperability, and reuse of the digital assets,⁵ our workshop roundtable also raised the question if it is necessary to feed the “obsession” for paradata and the “sense of guilt” of those who produce models for which the display of paradata is not given the same time, attention (and thus money), as the model itself.⁶ After all, a similar level of scientific rigor and assumption of due diligence granted a scholar communicating through traditional media should be accorded to the scholar creating (and explaining the reasons underlying) a 3D model.

The editors of this volume hail from the discipline of art history—as also most of the authors. Those engaged in that discipline recognize that the technologies we are writing about have been the purview, for some time now, of heritage experts, archaeologists, architects, and preservationists. Indeed, the interdisciplinarity of digital approaches invites diverse conventions, and as the media used for digital visualizations are adopted and their hermeneutics contested by art historians, archeologists,

2 The most common usage implies that every reconstruction is a working hypothesis. See, for instance, Rodríguez-Gonzálvez *et al.* 2017.

3 Schreibman/Papadopoulos 2019.

4 The research group *Rome Transformed* has proposed thinking of these models as provocations: “We term our visualisations ‘provocations’, because while they are digitally rebuilt with software that ensures that they are structurally viable and represent the team members’ best

efforts to understand the data, we stress that visualisations of ancient buildings and landscapes can never be absolutely accurate. The models are generated to provoke a response, to facilitate challenge from colleagues on any point of detail or underpinning assumption. We believe that the discipline of producing the best models we can helps us to test interpretations. Accordingly, these visualisations should not be regarded as definitive or final products,

but rather advanced visual prompts to advance the testing of hypotheses.” See: <https://rometrans.ncl.ac.uk/rtsciedoc/>.

5 The FAIR Principles: <https://www.go-fair.org/fair-principles/>.

6 By “paradata” we intend the data associated with a model including the primary and secondary sources used to generate it.

preservationists, and cultural heritage experts, the resulting epistemes are naturally hybrid.

This is evident by the variety of authors and approaches collected here. The contributions in this volume at once offer case studies, celebrate, problematize, and call into question the adoption of digital models across various humanistic disciplines. The article by Giacomo Landeschi⁷ combines 3D models and Geographical Information Systems (GIS) to evaluate the symbolic values connected to an architectural space from ancient Pompeii. In collaboration with the *Lateran Project*, Lex Bosman⁸ employs laser scans and Ground Penetrating Radar (GPR) research to generate a 3D reconstruction of Rome's Basilica of St. John at the Lateran, which, in turn, encourages new hypotheses and prompts discussion about colors, materials, lighting, and atmospheric elements. Another Roman Basilica, St. Paul's Outside the Walls, is the subject of Nicola Camerlenghi's⁹ efforts to develop an intuitive, peer-reviewable digital reconstruction, which delivers content through embodied experiences and exploratory learning. Fabrizio Nevola, Chiara Capulli, Donal Cooper, and Luca Brunke¹⁰ demonstrate how digital tools help to investigate the role of the Brunelleschi's Ospedale degli Innocenti in the social and artistic life of Renaissance Florence from the wider urban context down to individual decorative elements in the building interior. Andrea Giordano and Paolo Borin¹¹ present the *Visualizing Cities* project, a collaborative, multi-institutional effort to revolutionize research and teaching by interpreting, representing, and fostering the understanding of cities through digital technologies. After years of recontextualizing the wall paintings, mosaics, and panel paintings of medieval Rome's sacred buildings through digital technologies, Giulia Bordi¹² presents a new venture—EHEM (Enhancement of Heritage Experiences: The Middle Ages. Digital Layered Models of Architecture and Mural Paintings over

Time), which develops virtual reconstructions of medieval artistic heritage as an instrument for researchers, restorers, heritage curators, and tourists. Angelica Federici¹³ focuses on yet another Roman Basilica, that of Sant'Agnese fuori le mura, in a virtual reality project that combines established tools of scholarly enquiry with photogrammetry/point cloud, CAD modeling and virtual reality to develop an open and discoverable model that is not as much a product, but a research tool. Based on the experience of the Palermo Royal Palace Project, Ruggero Longo¹⁴ presents the epistemological potentials of digital models as dynamic repositories for vast amount of research and conservation data, with a critical reflection about issues of accessibility and sustainability over time. Piotr Kuriczynski's¹⁵ contribution addresses reconstructive source-based 3D models as research tools, from the experience developed in the field of contemporary engineering and urban planning; he calls for the definition of shared standards and the affirmation of what he defines "serious" 3D models of historic urban spaces and architecture.

As with any evolving practice, there remain a series of still open questions: What are the benefits of adopting an ontology that drives workflows and standardizes methods and protocols? Much effort has been made to formulate common paths (for example, the 2006–2009 London Charter for the computer visualization of cultural heritage or the 2011 Sevilla Principles of virtual archaeology),¹⁶ but these are now in the remote past by digital standards, and new stakeholders are at play. Another unresolved matter is how best to combine textual and visual data with digital 3D models to enable users to better engage with the specificity of historical sources and the heuristics of the digital result—essentially what is the equivalent of a footnote or endnote for 3D models?¹⁷ This is at the core,

7 Landeschi 2023.

8 Bosman 2023.

9 Camerlenghi 2023.

10 Nevola et al. 2023.

11 Giordano/Borin 2023.

12 Bordi 2023.

13 Federici 2023.

14 Longo 2023.

15 Kuroczyński 2023.

16 <https://www.londoncharter.org/index.html>; <http://sevilleprinciples.com>

17 A rather visual and spatial way of cataloging visual evidence is evident in the Urban History 4D projects, with the developed case study of Dresden: <https://4dbrowser.urbanhistory4d.org/>. For annotating

images associated with models, see the "Scientific Documentation for Decisions. The Reconstruction Argumentation Method" developed by Marc Grellert and Mieke Pfarr-Harfst at the Technische Universität, Darmstadt: <http://www.sciedoc.org/>.

not only of the pedagogic potential of these models, but also central to evaluate the validity and reliability of digital models and visualizations in a peer-reviewed fashion. We express optimism that as more scholars develop 3D models, there will be a larger community willing and able to offer constructive peer reviews and paradigmatic examples will emerge.

As a cutting-edge tool, a 3D model is often on the frontlines of teaching and popularizing our disciplines, particularly among younger generations. Indeed, we must consider the training of future scholars, without losing the richness of traditional approaches. But new generations should acquire the skills necessary to integrate the sorts of models treated here into their research and teaching. And if not teach the competences to create basic models themselves—a task that may remain a collaborative effort—we should at least convey the methodological and epistemological concepts at the heart of such digital approaches to the arts.

Finally, there is the pressing concern of our time—sustainability—and its role in the production and retention of digital models. While not quite the burning of the Library at Alexandria, the start of 2021 brought one of greatest data losses in history. It is seldom noted and lamented that when Adobe Flash plug-ins were no longer being supported by web browsers, all websites that operated with Flash lost their interactive capabilities, which for many was their lifeline—it is how they communicated data to their users and how users interacted with the data.¹⁸ Without an eye toward sustainability, websites and digital publications that include 3D models risk sliding toward a similar form of digital oblivion.¹⁹

An additional challenge to future proofing is compounded by our growing awareness of the climatological impact of data creation, storage, and maintenance required of digital projects.

While art historians are generally trained in the tradition of single-authored research, digital modeling projects tend to be collaborative, transdisciplinary ventures on account of the specific expertise required for their development. It is not only a matter of agreeing on defining the output of representation and the underpinning data: before that, it also requires self-critical reflection and questioning of different disciplinary perspectives. Digital 3D models create meeting points between disciplines where shared research and technology problems are addressed so that new questions arise. Developed outside the comfort zone of one's own discipline, such models create a space for theoretical, methodological, and epistemological opportunities, perhaps more so than an actual physical space. Accordingly, we might consider the 3D model as a “dynamic and rhizomatic knowledge site”²⁰ across the disciplines involved. Hence, the inherent challenge for art historians to both explore and expand a discipline, which on account of its transdisciplinary nature has few defined boundaries.

The editors wish to thank the personnel of the Bibliotheca Hertziana (especially Raffaele Rossi), all our speakers, and the participants of the discussion and roundtable who inspired our debate and these reflections. For this publication, we are grateful to Elisa Bastianello, who served as digital publication manager and to Franziska Kleine for her editorial and digitization work. Thanks also to Anna Parlani and Cecilia Goletti.

¹⁸ To take examples related to Rome, the Nolli website and the Waters of Rome website, each of which used maps to convey information about the Eternal City were essentially boarded up and rendered inaccessible. Both have since had to secure thousands of dollars of funding to represent themselves in a 2.0 version. Nolli website has been recently republished (<https://web.stanford.edu/group/spatialhistory/nolli/>),

while Waters of Rome will soon be.

¹⁹ The question of sustainability as well as that of shared standards and transparency of paradata were topics for discussion of the recent conference *The Future of the Virtual Past. New Directions and Shared Standards in the Reconstruction of the Medieval-Renaissance Built Environment* (Cambridge, Jesus College, 27 June 2022), organized by Donal Cooper and Morgan Ng with Tanja

Michalsky, Elisabetta Scirocco, Roberto Cipolla, and Deborah Howard <https://www.futureofthevirtualpast.com/> (WBM <https://web.archive.org/web/20220712202657/https://www.futureofthevirtualpast.com/>).

²⁰ The definition is applied by (Schreibman/Papadopoulos 2019, but with reference to Digital Scholarly Editions, which they propose as possible models for the publication of 3D (re)constructions.

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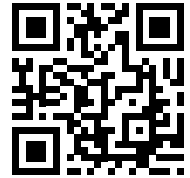
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Abstract

Giacomo Landeschi

What is a 3D Model and Why Do We Model? Some Reflections Built Upon Archaeological Case Studies

keywords – 3D modeling, Gis, Spatial Analysis, Virtual Reality, Pompeii



This article discusses the role of digital 3d models and spatial analysis for the study of ancient space. Drawing upon archaeological case studies, the aim is to reflect on theoretical and methodological issues that have long characterized the debate over the use of three-dimensionality in the study of ancient space. Nowadays 3d models are ubiquitous, with an increasing number of practitioners in the field of Cultural Heritage creating their own 3D contents and sharing them through online repositories with a diverse audience including researchers, students, and public. Still, whether data visualization and dissemination are important aspects to cover, to draw real advantage from the third dimension it is crucial to reflect on its heuristic value and the opportunities it can open for research. The proposed work pipeline combines 3d models and Geographical Information Systems (Gis) to analyze archaeological objects in their contextual space in order to address specific research questions that include the evaluation of any symbolic value connected to the architectural space of a Pompeian house.

Doi: [10.48431/hsah.0202](https://doi.org/10.48431/hsah.0202)

What is a 3D Model and Why Do We Model? Some Reflections Built Upon Archaeological Case Studies

Giacomo Landeschi

Following a commonly agreed definition, the term ‘model’ refers to a process of simplification of something more complex to enable understanding. Different techniques, including predictive modeling, least-cost path and viewshed analysis have long been used in archaeology to investigate the human past and to gain new knowledge about the (pre)historic landscape. In recent years, the development of more advanced hardware and software solutions allowed archaeologists, art historians and cultural heritage specialists to deal with complex forms of data representation, which include 3D boundary and volumetric models. Despite this form of data is now becoming ubiquitous, a real discussion of the theoretical and methodological implications connected to the use and misuse of 3D data in our discipline has yet to occur. One question is particularly urgent: what is the heuristic value of 3D modeling and how can we benefit from three-dimensionality for increasing our understanding of the past? How can we overcome the traditional picture of 3D technology as a mere tool for improving the user’s visualization experience and try to set new standards and best practices in order to take advantage of 3D models as additional exploratory tools? Drawing upon the experience matured at Lund University, we investigate the potential of 3D-based spatial analysis for addressing specific research questions: monitoring endangered heritage sites, re-enacting excavated stratigraphic sequences, assessing the multisensory engagement within a digitally reconstructed space of the past.

Material Culture and the Role of Affordances

The ancient space is not a static, immanent entity and it cannot be fully understood without considering the role played by its original inhabitants. Drawing upon this concept, it is the duty of an archaeologist to question current analytic methods and interrogate him/herself on what effective contribution can be brought by computational approaches to the study of the past as a lived space made by people, encounters, relationships, but also affections and emotions.

To cope with this issue, we should pay attention to three key elements: material culture, affordance, and modeling. As for material culture, intended as any material manifestation of (past) human activity, it is no surprise that it constitutes the main focus of archaeological investigation, being an essential source of information to connect ourselves with the mindsets of people from the past. Still, material culture does not tell us very much if we cannot grasp the intended meaning behind the object and possibilities of actions it can afford. That is why affordance plays an important role in this process of knowledge production: it is the way for us to ‘read’ a meaning of an object by interpreting its visual properties and so to infer about functions and actions that it could have ‘facilitated’.¹

Then the question that arises is about the strategy to put in place to deal with affordances and the relational space where past peoples lived. Modeling becomes a crucial element for this

¹ Gillings 2012; Gibson 1977.

purpose: according to Gary Lock,² a model is a simplification of more complex phenomena, made to enable the process of understanding. Modeling in its different forms, including surveying, drawing, has been widely used in archaeology (long before digital methods were introduced) as a standard practice to document and analyze the visual and material characteristics of an object, a monument or a landscape.³ Whether most of modeling processes have long been aimed at imitating the reality of the past,⁴ the real challenge nowadays is to simulate aspects of past realities⁵ (including the immaterial ones) and try to build scenarios where it is possible to adopt formal methods of analysis to better understand how that space was used by its original inhabitants.

GIS and 3D Spatial Analysis

In this respect, 3D data and Geographical Information Systems represent a viable solution as they provide users with an array of tools to visualize and, most remarkably, to analyze the archaeological landscape from a contextual/situated perspective.

Research conducted at Lund University has sought to demonstrate how three-dimensionality can be used as a heuristic tool to fulfill several research questions and to redefine archaeological practice. There are, in particular, a few research areas on which we have focused our attention. These include:

1. Risk assessment for endangered heritage sites;⁶
2. Re-interpretation of legacy data in an original way;⁷
3. Investigation of the symbolic dimension of ancient space;⁸
4. Analysis of marginalized aspects of past reality such as the 'emptyscape', or secludedness.

Through these projects we have sought to demonstrate how three-dimensionality can be employed as an effective analytic tool to

further our understanding of well-defined archaeological problems. Indeed, 3D data are nowadays ubiquitous in archaeology and are rapidly becoming a de-facto standard for site documentation in many different contexts spanning from research-led projects to cultural resource management enterprises. Still, the use of 3D models is often limited to improving the visualization experience of a user and communication of Cultural Heritage-related contents.¹⁰ There are obviously significant limitations that we must be aware of when it comes to data representation both in 3D modeling and GIS which span from the lack of transparency in model reconstruction, to the inadequacy of digital mapping to represent the reality of the past.¹¹ Nevertheless, the recent developments in 3D-informed GIS technology led to the possibility of managing 3D boundary models in a geodatabase management system (GDBMS) and to take advantage of GIS-based spatial analytic tools for a thorough and contextual investigation of the virtually reconstructed space of the past.

Towards a Heuristic Approach?

A case study in Pompeii was developed to test a novel method by which to investigate the social dimension of the ancient space through the analysis of the visual impact of a wall painting and by defining innovative workflows for the study and the analysis of the domestic household in Pompeii. This was achieved by taking a situated perspective of potential observers moving and interacting within the house. As thoroughly described in recent publications,¹² a wall painting describing an erotic scene was examined in a 3D GIS environment to better understand its visual impact within the space of the peristyle. Interestingly, by running a fully-3D Line-of-Sight (LOS) analysis, it was possible to determine both the number of hypothetical locations which provided a direct view to the fresco as well as the percentage of fresco's surface that was visible by the different standing points (fig. 1). Such an approach allowed us to raise new interpretations about the location

2 Lock 1995.

3 Dell'Unto/Landeschi 2022.

4 Gillings/Goodrick 1996.

5 Forte 2011.

6 Campanaro *et al.* 2015.

7 Landeschi *et al.* 2019.

8 Landeschi *et al.* 2016.

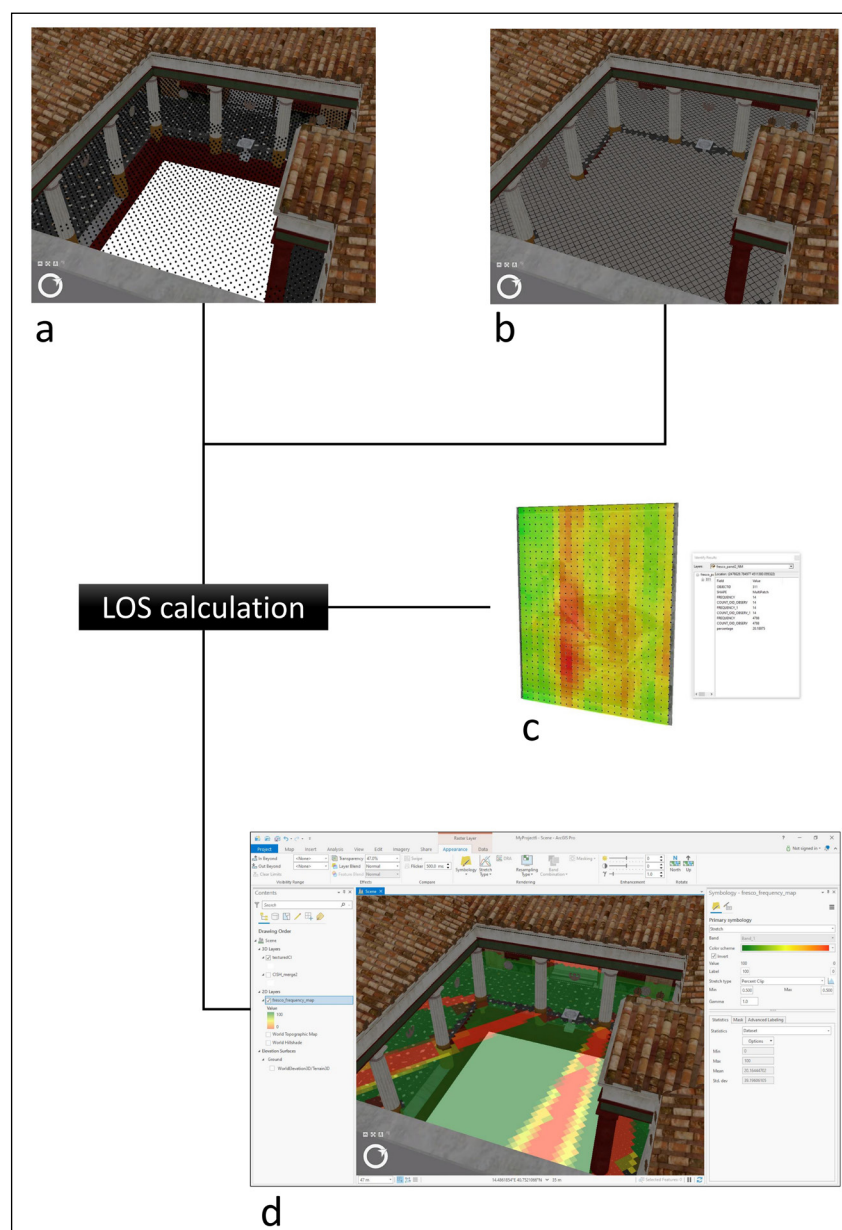
9 Landeschi 2019.

10 Frischer 2008.

11 Llobera 2012.

12 Landeschi 2019; Landeschi *et al.* 2016.

Figure 1
Workflow for Line-of-Sight (Los) analysis in
Gis (ArcGIS Desktop/Pro software release):
(a) setup of hypothetical observing points,
evenly distributed through the space of the
virtually reconstructed house of Caecilius
lucundus (height on the ground floor 1.65
m, space interval 0.2 m). (b) vector panels
defining the horizontal grid of analysis.
Los algorithm enabled us to generate (c)
a vertical map of visual exposure of the
fresco's surface and (d) a horizontal map of
cumulative visibility of the fresco from each
observing location.
From Landeschi *et al.* 2016.



and the symbolic significance of the examined artifact: its seemingly prominent position (it was originally located on the wall just next to the dining room entrance) was not so visible as we would have expected just by examining it on a traditional map plan. This was due to the presence of columns and other vertical visual obstacles that would have prevented a passerby from clearly recognizing figures and scenes represented in the wall painting. In addition, another problem was posed by the narrowness of the visual angle for those observing from locations situated too close to the peristyle wall where the fresco was placed.

In brief, this approach allowed us to redis-
cuss on a more general level, the problem of
visibility studies in archaeology and the use
of computational methods for simulating
sensory perception in a digitally reconstructed
space of the past. Interestingly, one of most
neglected aspect is that of visual acuity¹³ (and
the way it affects human sight and its capa-
bility of discerning details of objects. Natural
and artificial light, as illustrated recently by
Papadopoulos and Moyes¹⁴ is also an element
that is often dismissed from most visibility
studies conducted in archaeology and cultural
heritage.¹⁵ For these reasons, as a further stage

¹³ Ogburn 2006; Bernardini *et al.* 2013.

¹⁴ Papadopoulos/Moyes 2021.

¹⁵ Gillings/Wheatley 2020; Cassatella/
Carlone 2013.

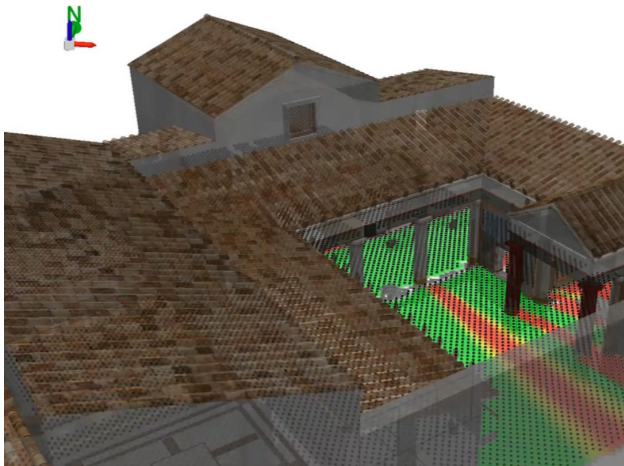


Figure 2

Workflow for Line-of-Sight (LoS) analysis in Gis (ArcGis Desktop/ PRO software release): the video <https://doi.org/10.17617/3.BxTD5K> shows the setup of hypothetical observing points, evenly distributed through the space of the virtually reconstructed house of Caecilius lucundus (height on the ground floor 1.65 m, space interval 0.2 m). LoS algorithm enabled us to generate a vertical map featuring the percentage of visual exposure of the fresco's surface and a horizontal map of cumulative visibility of the fresco from each observing location. From Landeschi *et al.* 2016.

of this research, we have been recently testing innovative methods for measuring visual attention in the attempt to deal with the issue of visual acuity and illumination effects. This was made possible by integrating Virtual Reality, Eye-Tracking technology, and 3D GIS. Although we are at a very preliminary phase of the research, a workflow (fig. 2) has been defined and a few measurements were performed on a very limited number of sample users, who were asked to walk through the virtual space of a Pompeian house (Casa degli Epigrammi Greci),¹⁶ and perform different tasks in order

to analyze their visual behavior in relation to architectural and iconographic details visible in the reconstructed space of the house.¹⁷

To sum up, this experiment allowed us to define new strategies for an experiential investigation of an ancient built space, where the use of modeling and three-dimensionality played a pivotal role and where combined methods allowed archaeologists to raise new interpretations and pose new questions about limitations and possibilities for future research around 3D-based spatial analysis applied to Cultural Heritage sites.

¹⁶ Staub Gierow 2008; Staub 2009.

¹⁷ Campanaro/Landeschi 2022.

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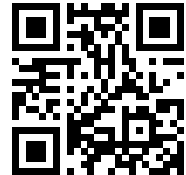
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Abstract

Lex Bosman

The Fourth–Century San Giovanni in Laterano in the Twenty–First Century: Digital Approaches and Reconstruction

keywords – 3D reconstruction model, Early Christian architecture, San Giovanni in Laterano, GPR research



A few important elements in the reconstruction of the early Christian church of San Giovanni in Laterano justified new research: how certain was the reconstruction with lower spaces to either side of the main altar area where later in the Middle Ages the transept would be built? Combined with the existence of two giallo antico marble columns in the actual building this problem justified a new reconstruction. The already operating Lateran Project of Ian Haynes and Paolo Liverani offered the possibility to combine our research and our research methods. With laser–scan and GPR research the tools were available to build a 3D reconstruction, making use of new digital tools and approaches as well as more classical methods. Since the data obtained by Richard Krautheimer and his team proved to be less accurate, the new data provided by the Lateran Project was the best basis on which to build a 3D reconstruction. Our research also showed that a large foundation wall underneath the present south transept had never been considered in reconstructions; the GPR research showed that on the north side a similar foundation wall most likely exists. Building a 3D reconstruction model was the best way to find out if the giallo antico columns and two other shafts could have been used as continuation of the colonnade between the inner and the outer aisles. Contrary to reconstruction drawings, our 3D model also encourages discussion about things like the color of the materials, atmospheric elements, etc.

Doi: [10.48431/hsah.0203](https://doi.org/10.48431/hsah.0203)

The Fourth-Century San Giovanni in Laterano in the Twenty-First Century: Digital Approaches and Reconstruction

Lex Bosman

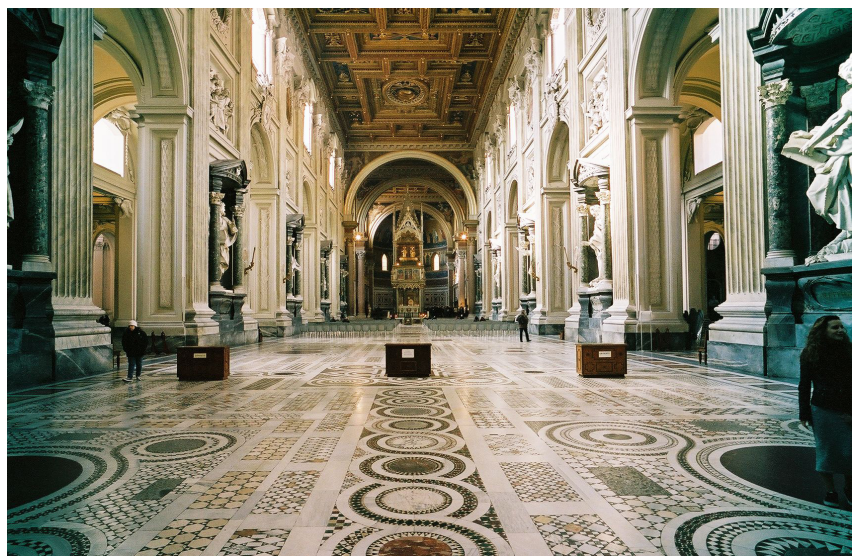
San Giovanni in Laterano was constructed as the first large Basilica in the city of Rome and as the first cathedral for the city's Christian community. First built in the early 4th century, this church building still exists, albeit with many changes made during its long existence (fig. 1). So why would one bother to build a 3D model of this Basilica, which can still be visited after all? The façade was built in the 18th century by architect Alessandro Galilei, whereas the interior as it appears today is largely the result of the renovation of the building by Francesco Borromini. To put it simply: we can state that the spatial structure to a large extent is still that of the fourth century, but the architecture of the Basilica was changed several times. A major change has been the building in the Middle Ages of the transept on the west side.

A legitimate question, of course, is what we wanted to find and which questions were not yet answered by previous research, in other words, what was the purpose of the research project? We

focused on the early phases of the construction history of the Basilica and one of the interesting and most important items was the connection of the Christian Basilica with earlier structures.

The research began with the so-called Lateran Project, which was initiated and led by Ian Haynes (Newcastle University) and Paolo Liverani (University of Florence).¹ The archaeological area underneath San Giovanni in Laterano is important for the study of transformations of the area and its buildings in Severan times, not least to understand the chronology of the buildings. A domus seems to have been the first built structure, which was then succeeded by the castra of the Equites Singulares and from 312 onward the Christian Basilica was built, which we know as San Giovanni in Laterano. And although large parts of the scavi area have been archaeologically researched, many parts were not very well understood, nor were the interconnections of various building elements very clear. Moreover, large parts of the archaeological

Figure 1
Rome, San Giovanni in Laterano, interior to the west.
Photo: L. Bosman.



¹ From 2012 onwards reports of the Lateran Project were regularly published, see the publications listed under Haynes, I.P. in the

bibliography of Bosman/Haynes/Liverani 2020, pp. 549–550.

area are not visible or accessible because of large height differences. The aim of the Lateran Project was: to develop a fully comprehensive survey and analysis of the complex of archaeological material underneath the Basilica of San Giovanni in Laterano. The use of new, digital methods was fundamental in this research that stretched over more than ten years.²

With laser scanning and GPS-fixed data the whole of the archaeological area has been brought to life, with fascinating material to be newly studied. Since no complete and general documentation maps and reports were compiled when the area was originally excavated, mainly in the 1930s and some in the 1950s, now for the first time many elements of the excavation area could be seriously studied. With laser-scan technology, the area was recorded, which allowed us to study all kinds of elements that had not been accessible since they were first excavated.

At a later stage, I joined the team to offer considerations on the architecture of the early Christian Basilica, given that I had been working for some time on reconstructions of the Basilica in its initial phase during the fourth century. The reconstruction by Richard Krautheimer of the early Christian Basilica is generally accepted and certainly convincing, yet several critical items needed more clarification.³ These can be formulated in basic but crucial questions: what was the archaeological basis for the reconstructions of the shell and of the interior space of the Basilica? And, what do we know about the material and the color of the columns that were initially used?

My contribution to and main concern with the team of the Lateran Project was to build a 3D model, based on solid data in order to either confirm or correct existing reconstructions of the Basilica, and with as much detail as seemed both possible and necessary. Eventually this 3D model was built by Iwan Peverett, with myself, Paolo Liverani and Ian Haynes as authors. This made up a good team, since Peverett is trained as an architect and works with 3D programs to build detailed models, Liverani and Haynes

are archaeologists, and I am an architectural historian. Once the scanning of the scavi area and of the actual church building was finished, we decided to build a 3D model. It was Iwan Peverett who ultimately did the important digital 3D construction work. In several inspiring sessions the most difficult choices were tried and discussed in preliminary models, to evaluate the consequences for the architecture of these choices.

So the Lateran Project as a whole employed conventional methods combined with modern digital ones. As already mentioned, the lack of documentation of the digs in the 1930s and 1950s hampered further research and that is where modern techniques came in. Let me further explain my preoccupation with the reconstruction of the Basilica from the early 4th century. I felt unhappy with the western part of the ground plan as reconstructed by Richard Krautheimer. In that reconstructed ground plan the parts to either side of the main altar area, where, much later, the transept would be built, show L-shaped spaces which are not a feature of contemporary or older basilicas. On top of that, the history of the use of several column shafts was a fascinating point of interest. When studied in connection with each other both ground plan and column shafts could possibly add improvements to the reconstruction. Two column shafts of the *giallo antico* marble have supported the organ tribune in the northern transept since the late 16th century. The use of these columns can be traced back to the 12th century in the complex of San Giovanni in Laterano. The exact same type of these marble column shafts of 24 Roman feet (7.14 m) in length, 3 feet in diameter (0.89 m) and with 24 flutings are only to be found on the Arch of Constantine, which dates from 315.⁴ Knowing that Emperor Constantine was seriously involved in the planning and construction of the Basilica and that the Arch built in his honor could not very well have been realized without involvement of Constantine and his advisors, a connection between the building material used in both the Basilica and the Arch seems more than likely.

2 On the spatial history of the Lateran and the use of new research methods see, for instance,

Liverani 2020 and Haynes/Liverani 2020.

3 Krautheimer/Corbett/Frazer 1977.

4 Bosman 2020, pp. 183–185.

Figure 2
Rome, San Giovanni in Laterano, Plan of
foundations in southwestern part, with
indication of wall B.
Drawing in Krautheimer/Corbett/Frazer 1977.

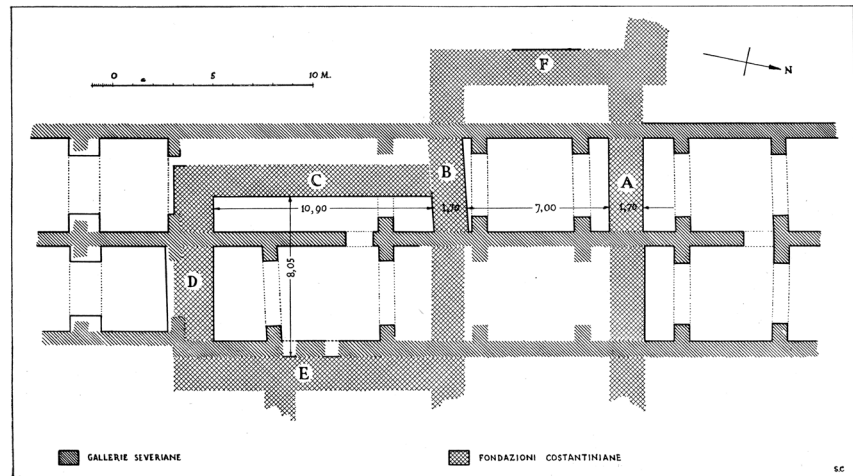
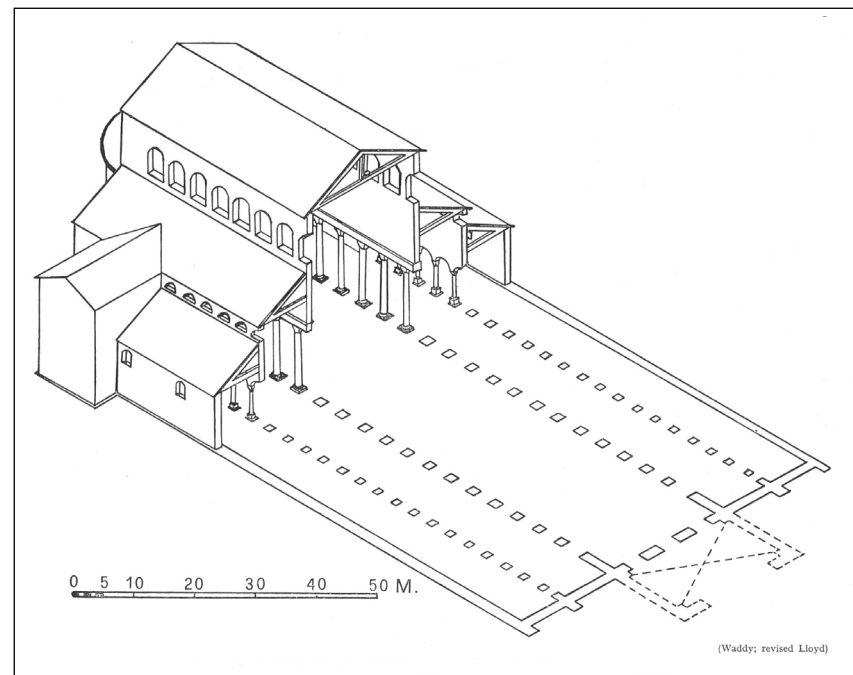


Figure 3
Rome, San Giovanni in Laterano,
reconstruction by Richard Krautheimer.
Drawing in Krautheimer/Corbett/Frazer 1977.



This, in turn, gave rise to a new hypothesis that these columns—at least two of yellow marble, which are still to be seen, and at least one of white marble—had been used in the original Basilica from 312 onward. Of three possible locations, the one that was most likely was on top of the so-called “wall B,” which exists in the excavation area underneath the present southern transept of the Basilica, but which never featured in previous reconstructions (fig. 2).⁵ This presents the question of whether the columns could initially have been used as a continuation of the colonnades between both aisles on either side with “wall B” serving as

their foundational support on the south side. Coincidentally, the published and famous reconstruction drawings of the early Christian Basilica always obscure the part of the interior where I hypothesized the use of these column shafts (fig. 3).⁶ That was another important reason to desire a 3D model that would allow us to visualize the consequences of this hypothesis much better than line drawings would be able to do, since a 3D model does not obscure any part of the construction.

So at first I planned to prepare a 3D model with data from the famous *Corpus Basilicarum*

5 Bosman 2020, p. 189; Claussen 2008, pp. 26, 166.

6 Not only Krautheimer's drawing, but for instance also those in Blaauw 1994, vol. II fig.

2 and Brandenburg 2004, p. 261 do not show the architectural details in that specific part of the Basilica.

Christianarum volume by Richard Krautheimer along with the research team. I assumed that the least of my worries would be the essential data about the early Christian Basilica, which we imagined could be extracted from Krautheimer's book, but that turned out to be different. When assembling the remarks about the measurements of the Basilica and its details and re-calculating them a difference appeared, at first sight of minimal importance, but when calculated on the length of the Basilica of some 300 feet, the difference between the smallest and the largest foot was simply too inaccurate. Krautheimer apparently used a small foot of 0.294339 m and a larger foot of 0.298630 m, the distinction of which shows a difference of 1.28 m when applied to the 300-foot length of the Basilica.

The accurate data assembled and used by the Lateran project then showed their importance, which allowed us to reconstruct the Basilica more accurately than before. From the start, the aim for our 3D model was to use it as a research tool, which would stimulate new questions to be examined. Several of our aims with the model can be summed up as follows:

- to aid in my reconstruction of the western part of the Basilica where—in later centuries—the transept would be constructed, and where I reconstruct the continuation of the colonnades between the inner and the outer aisles;
- to research if the written sources about adornments such as altars, lights and other elements in the interior were reliable in their detail;
- to research the effects of the colorful materials used in the pavement, the wall revetment, and the column shafts;
- to research if it were possible—within the limits of serious scholarship—to reconstruct the Basilica in 3D by combining the original structure, scattered elements no longer in their original position, written sources, depictions, archaeological data, and additional GPR (Ground Penetrating Radar) data.⁷

The archaeological area underneath the Basilica houses lots of small elements like pieces of pavements, but for the majority of these scattered pieces it is unknown exactly where they were found. That makes it very difficult and mostly impossible to re-integrate such elements in a virtual early Christian Basilica.

But let us return to the yellow marble column shafts mentioned earlier. It is one thing to indicate the assumed position of these shafts in a ground plan, but to visualize how that position would affect the construction of the Basilica as a whole is another thing altogether. The foundation wall known as “wall B,” which I mentioned earlier, was never seen as part of any reconstruction of the early Christian Basilica of San Giovanni. Whereas this “wall B” was excavated and is still in its position, a possible and likely counterpart on the northern side is unknown, since in the northern transept no archaeological research has ever been undertaken. During research in January 2016, when Salvatore Piro of the Consiglio Nazionale delle Ricerche, well-known expert in GPR, surveyed important areas within the Basilica, it was possible to scan the northern transept area as well. The result of the GPR-research was extremely interesting, when Salvatore Piro told us that a wall or a foundation must be present in the position symmetrical to “wall B” found on the south side (fig. 4). That was of great importance, since it lent further credence to my reconstruction (fig. 5).⁸

We then had the material to build the 3D model, and during the construction of this model we had to decide on specific elements. An important starting point for us was that reference examples—used to understand and reconstruct specific features like windows—should predate or be concurrent to San Giovanni. Richard Krautheimer had been using another point of departure for his reconstruction: since San Giovanni is more or less 5/6 of the volume of the early Christian St. Peter's, he reduced the Vatican Basilica to reach a credible and acceptable reconstruction of San Giovanni. But there is at least one serious disadvantage to that approach. One can question the use of the

⁷ Cf. Piro et al. 2020.

⁸ Bosman 2020, pp. 189–190.

Figure 4
Rome, San Giovanni in Laterano, GPR survey
by Salvatore Piro.
Image by Lateran Project, S. Piro.

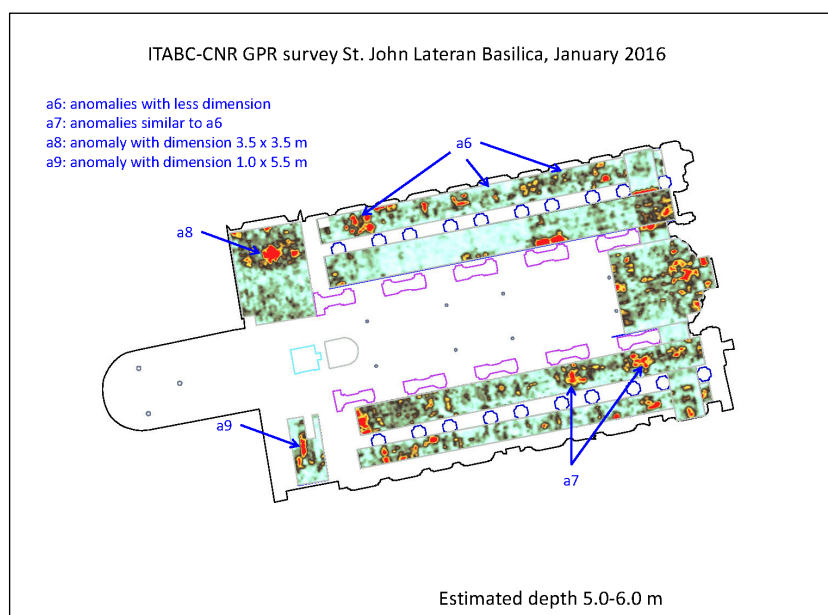
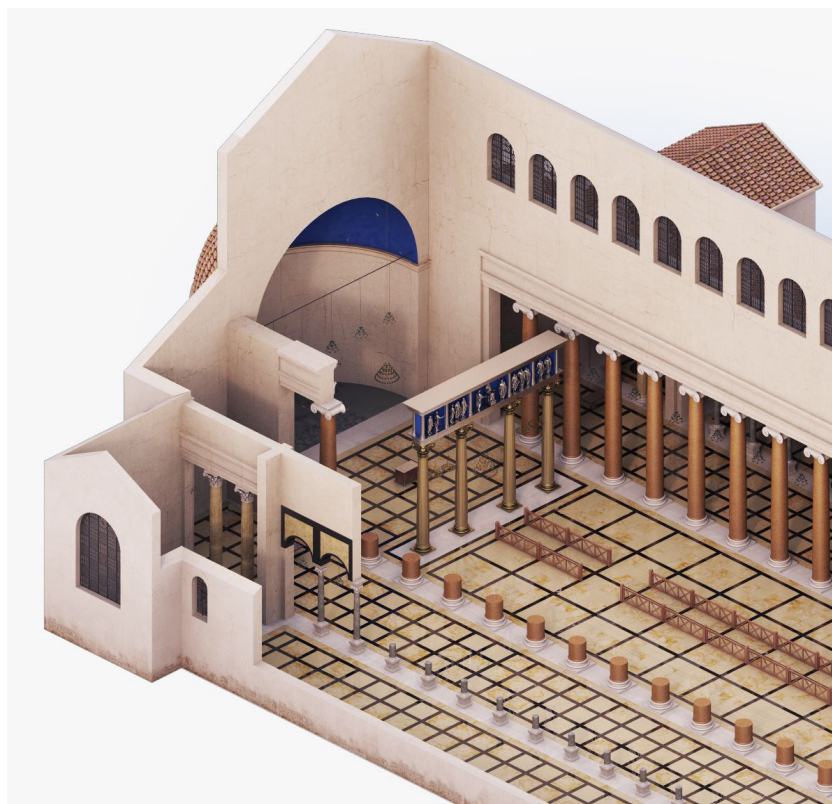


Figure 5.
Rome, San Giovanni in Laterano, open
axonometric view of southwestern part.
Reconstruction by L. Bosman; 3D model and
image by I. Peverett.



Vatican Basilica as model for the Lateran one, since the construction of the latter began some ten years before that of the former. We wanted to avoid this reversal of chronology.⁹

We made use of concept models to discuss various elements, like the volume of the whole Basilica, and the roof on the aisles, which also in past reconstructions led to the question of

whether each side aisle was covered by separate roofs, or a continuous one on either side. The semi-circular windows in the upper walls separating the inner from the outer aisles which began to appear in reconstructions apparently modeled after the famous fresco of the interior of San Giovanni in Laterano by Filippo Gagliardi in S. Martino ai Monti were not seriously

⁹ On our reconstruction see Bosman *et al.* 2020, pp. 145–150.

questioned in the past. However, in our view the fresco, interesting though it may be, shows too many inaccuracies in the representation of the interior to accept details like the semi-circular windows as proof for the existence of such windows in the Lateran Basilica. The building itself does not show any signs or remains of such windows and it should not be forgotten that Gagliardi painted an interior that he himself had never seen—his fresco is a “reconstruction.” Ultimately this meant that we rejected the fresco as a reliable source for scholarly reconstructions, accordingly the semi-circular windows were rejected as well. Hence they do not appear in our reconstruction model.

The 3D reconstruction model we built is meant to invoke new insights and new questions, one of which is the viability of generating a detailed 3D reconstruction in color. According to some colleagues, such a 3D model might look “perfect” and complete in such a way that—instead of inspiring new questions—it would appear so convincing that no elements or details are questioned anymore. One can also wonder about the importance of conveying information about details of the modeling process. For us, considering the purpose of the model has offered guidance in these matters. One of the main advantages of a colorful and detailed 3D model like ours, is that we feel the need to explain and justify the choices we have made. In the past, it seems that by presenting a reconstruction in the format of a black-and-white line drawing, the need to explain and justify specific choices was given far less attention, but the basic starting point remains the same. Every kind of reconstruction is meant to visualize the most likely possibility to the eyes of the author, whether it is a black-and-white line drawing or a color 3D reconstruction, and, in both cases, the choices that were made should be explained. 3D digital reconstructions and visualizations have made this point more important in modern scholarship. In our volume on the Lateran Basilica we tried to be transparent about the choices we made, several of which are discussed in this paper as well.

Let me briefly mention a few of the most important choices that were made. For the number of windows in the clerestory we simply opted for one window for each bay, which seems reasonable; this is not a new kind of design for such a basilica. Our initial floor was criticized at the September 2016 conference and rightly so. Here, however, a serious challenge is that not many examples that can be used as inspiration are known. The Basilica Ulpia and Basilica of Maxentius / Constantine were important buildings in their time, both predating the Lateran Basilica, and their floors have been reconstructed in a very reliable way. For the revision of the initial reconstruction of the pavement we used these two models and the result is now much more in harmony with those two other floors.

Once we rejected the Gagliardi fresco as a reliable source, we lost the only evidence for variations in the types of capitals present in the nave. A post-medieval source mentions ionic capitals and because no older written or visual sources inform us about the capitals, we have chosen to adopt uniform rows of ionic capitals. This is a choice with important repercussions because the diverse capitals deployed in earlier reconstructions of the Lateran Basilica had been cited by some scholars as an important example of the *varietas*—a notion that now needs to be revisited.¹⁰ We have chosen to reconstruct an apse without windows, to stay close to the architecture of the apse of the Basilica of Maxentius/Constantine. At least much later in the Middle Ages windows were cut in the apse wall, but the unknown presence of those windows in the fourth century made us decide to not include windows. We know parts of the walls above the arches were clad with marble, but its color, height and pattern are unknown, which led us to reconstruct these interior elements in a simple manner. In 3D visualizations the point of view of human beings is not always taken into account. For the reconstruction of the lighting equipment this was an argument to reach a certain level of detail, the addition of atmospheric elements was yet another way to get closer to the way visitors

¹⁰ The notion of *varietas* has been proposed by Beat Brenk, cf. Brenk 1996. For the

anonymous source see: An., ‘Relazione dello stato nel quale si trovava la Basilica

Lateranense’, in: Lauer 1911, p. 585

may have seen and experienced the space. The positive and negative views on this specific feature and the scholarly debate about it may be brought forward by a model like ours (fig. 6).

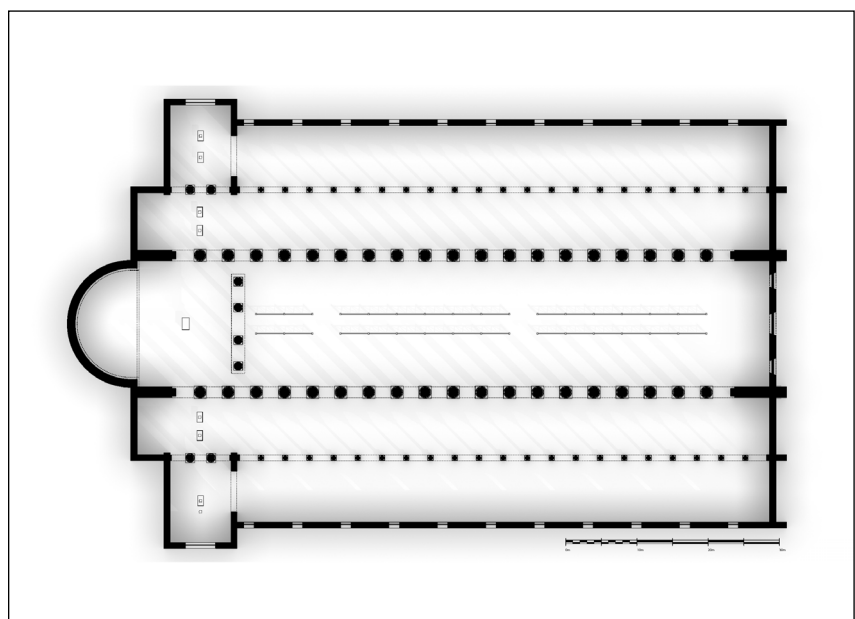
The main results of our joint project, which includes conventional methods and analysis, GPR-research, laser scanning with GPS fixed points for greater accuracy, 3D modeling for greater insight in architectural possibilities may now be summarized. The understanding of the connection between previous structures, namely the domus and castra, and the early Christian Basilica has been brought to a better and much more detailed level. Our 3D model of the Basilica helped to understand how the reconstruction of the newly added colonnades would be possible since the 3D model no longer obscures the specific architecture

and construction of this area, unlike previous reconstruction drawings published by several scholars. Likewise, we have ventured some interpretations about the effect of this revised architecture, specifically the colonnades, not only on the ground plan, but also on the way space was understood and experienced. Unfortunately, the specific function and use of the spaces on either side of the main altar area are unknown, but it seems likely that the seven altars mentioned in the *Liber Pontificalis* were placed in these spaces (fig. 7).¹¹ And finally, while we still do not know the exact thickness of the walls of the fourth-century Basilica, digital measurements throughout the actual Basilica confirmed that the original Basilica was largely built in a very accurate way in the first quarter of the fourth century.

Figure 6
Rome, San Giovanni in Laterano, interior of the Constantinian Basilica.
Reconstruction by L. Bosman, P. Liverani, I. Haynes and I. Peverett.



Figure 7
Rome, San Giovanni in Laterano, Ground plan of 4th century.
Reconstruction by L. Bosman, P. Liverani and I. Peverett.



¹¹ Blaauw 1994, pp. 143–146.

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Abstract

Angelica Federici

Visualizing Medieval Rome. The Basilica of
Sant'Agnese fuori le mura

keywords – *Digital Humanities, Middle Ages, Rome,
Virtual Reality, 3D modeling*



Digital visualization technologies, including laser printers, 3D modeling and virtual/augmented reality, have revolutionized our critical engagement with the visual arts. By contrast, building information and CAD modeling can extend our understanding of art and architecture by augmenting the three primary spatial dimensions (width, height, and depth) with time. The settlement of female communities in pre-existing structures, the loss of a significant number of convents and the perishable nature of the construction materials used, has too often impaired the study of female monastic architecture. VR Sant'Agnese combines established tools of scholarly enquiry, including but not limited to archival research, empirical display of extant objects, and meticulous study of building structures with photogrammetry/point cloud, CAD modeling and ultimately virtual reality. These 3D models set in motion a series of methodological and ontological issues which question all aspects of art history and force us to engage with new agendas for research. While the sustainability of Digital Humanities research is at the forefront of current debates, we should take a step back and ask ourselves what is the use of these models? How can we guarantee a best practice standard which balances out the need for accuracy with the aesthetic quality of the object itself? These models need to be live, open and discoverable and ultimately understood not as research products but as a research tool.

Doi: [10.48431/hsah.0204](https://doi.org/10.48431/hsah.0204)

Visualizing Medieval Rome. The Basilica of Sant'Agnese fuori le mura

Angelica Federici

Introduction

Digital visualization technologies, including laser printers, 3D modeling and virtual/augmented reality, have revolutionized our critical engagement with the visual arts.¹ For example, the transformation of physical spaces over time was originally approached through traditional building design, largely reliant upon 2D technical drawings (plans, elevation, sections). By contrast, building information and CAD modeling can extend our understanding of art and architecture by augmenting the three primary spatial dimensions (width, height, and depth) with time. The settlement of female communities in pre-existing structures, the loss of a significant number of convents and the perishable nature of the construction materials used, has too often impaired the study of female monastic architecture. For these reasons when it comes to women religious, fixed architectural schemes cannot be traced on the basis of surviving elements. *VR Sant'Agnese*, conducted under the supervision of Professor Giulia Bordi, combines established tools of scholarly enquiry, including but not limited to archival research, empirical display of extant objects, and meticulous study of building structures with photogrammetry/point cloud, CAD modeling and ultimately virtual reality.² This project aims to reconstruct the medieval guise of the monastery of Sant'Agnese fuori le mura in Rome, in an integrated study of architecture, liturgical furnishing and painting. It wishes to produce a precise spatial analysis that goes beyond the descriptive limit of photographic reproductions. By creating a 3D virtual model of the monastery in its late medieval appearance,

this application ultimately aims to be both a research tool and an interactive instrument to visit the monument.³

The monumental complex of Sant'Agnese fuori le mura rises over a small hilltop off the Via Nomentana on the outskirts of central Rome (fig. 1).⁴ Originally the site of an early Christian cemetery and of the burial of Saint Agnes herself, the area underwent a period of extensive development, promoted both by Constantine and his daughter Constantia, during the transition of the Roman Empire from paganism to Christianity. In 1112, Paschal II (1099–1118) installed a group of Benedictine nuns who occupied the complex for over three and a half centuries until they were eventually replaced by a community of monks in 1480. The current state and impression of the church is due to the restoration works carried out in the 19th century by Pope Pius IX ca. 1855–1856 (fig. 2).

Historical Data

As testified by a monumental inscription originally found in the choir and today sited in the stairway that connects the church to the convent, the church underwent a radical refurbishment in 1256. The inscription declares that in 1256 – on the feast of St. Vitalis – three altars dedicated to St. John the Baptist, St. John the Evangelist and St. Emerenziana were consecrated in the presence of Pope Alexander IV (1254–1261) and a large group of senior ecclesiastics. The inscription goes on to state that the entire female monastic community was present and mentions three members by name: Lucia *abbatissa*, Theodora *priorissa* and Jacoba *devota*

1 Bonacini 2011; Luigini/Panciroli 2018.

2 This investigation is currently being conducted for my postdoctoral research at the Department of Humanities of the Università degli Studi di Roma Tre.

3 This methodological approach is indebted to the pioneering work of the art historian Maria Andaloro together with her research team. See Andaloro 2006.

4 Ballardini 2018; Brandenburg 2004;

Covello 2018; Frutaz 1960; Krautheimer/Frankl/Corbett 1937; Gambuti 2014–2015; Saini/Ravignani 2004.



Figure 1
Rome, Sant'Agnese fuori le mura, exterior of the Basilica.
Photo by the Author.



Figure 2
Rome, Sant'Agnese fuori le mura, interior of the Basilica.
Photo by the Author.

moniali sacrista. These renovations included the construction of a Cosmatesque *schola cantorum*, fragments of which survive: i) in the stairway connecting the Basilica to the monastery (fig. 3); ii) in the convent's present day refectory (fig. 4); and iii) incorporated in the altar *paliotto* of one of the 16th century side chapels dedicated to St. Lawrence and St. Stephen (fig. 5).

Several authors account for the appearance of the late medieval church in great detail during the 16th century. These chronicles were particularly useful to retrace the appearance of the church and especially its choir enclosure between 1200–1400.⁵ The erudite Augustinian Onofrio Panvinio (1530–1568), an Italian historian and antiquary, librarian to Cardinal Alessandro Farnese (1520–1589), provides a detailed description of the church in the second

half of the sixteenth century. He describes a series of crucial elements, namely an *architrabe tesselatis* dividing the central nave from the presbytery, the two altars mentioned in the monumental inscription – the one on the right dedicated to St. John the Evangelist while the one to the left to St. John the Baptist – and the presence of “*picturis*” in the galleries.⁶

The Italian ecclesiastic Pompeo Ugonio (ca. 1545/1550–1614), who visited the church around the same time, describes two pulpits, the *pro evangelio* and *pro epistole*, respectively on the right and on the left of the *schola cantorum*, along with the third altar dedicated to St. Emerenziana mentioned in the 1256 inscription.⁷ He claims that this was found on the counter façade and apparently housed the celebrated 1256 dedicatory inscription. Ugonio also

5 Claussen 2002, pp. 64–65; Giesser 2017, 108–13; Romano 2017.

6 Onofrio Panvinio, *Schedae De Ecclesiis Urbis Romae*, BAV, Vat. lat. 6780, fol. 278r (transcription Santi Pesarini, Appunti copie, estratti e schede riguardanti in massima parte le chiese di Roma, BAV, Vat. lat. 13127,

fol. 454r); Claussen 2002, p. 64.

7 Pompeo Ugonio, *Compendio del Theatro della città di Roma*, BAV, Barb. lat. 2160, fol. 129v, 130r (transcription Santi Pesarini, Appunti copie, estratti e schede riguardanti in massima parte le chiese di Roma, BAV, Vat. lat. 13127, fol. 456r, 456v); Claussen

2002, p. 64; Pompeo Ugonio, *Theatrum Urbis Romae*, 1594, Biblioteca Comunale Ariostea di Ferrara, Classe I. 161, fol. 966 (transcription Santi Pesarini, Appunti copie, estratti e schede riguardanti in massima parte le chiese di Roma, BAV, Vat. lat. 13127, fol. 458r); Claussen 2002, p. 65.



Figure 3 (above)
Rome, Sant'Agnese fuori le mura, interior of the Basilica, monumental stairway, fragments of the *schola cantorum*. Photo by the Author.



Figure 4 (above)
Rome, Sant'Agnese fuori le mura, interior of the Basilica, refectory, fragments of the *schola cantorum*. Photo by the Author.



Figure 5 (right)
Rome, Sant'Agnese fuori le mura, interior of the Basilica, chapel of St. Lawrence and St. Stephen, fragments of the *schola cantorum*. Photo by the Author.

reports that the partition wall between the nave and the presbytery was raised by a step and consisted of panels decorated with mosaic.⁸ Three pillars each to the left and right of the central entrance to the presbytery area carried the final stone beam. These pillars were turned in their middle and set with colored mosaic stones. The archway was continued with two further columns in each of the two side aisles. In total there were ten columns that carried the temple beam in the full width of the church. This stone beam which separated the long house from the altar area was often part of the standard furnishings of Roman churches between the 12th and 13th centuries.⁹ The 1256 renovations of Sant'Agnese, however, also marked a larger refurbishment of the Basilica and the convent that probably extended over a considerable period of time and included fresco cycles both in the church and in the nuns' conventual spaces. Two fresco cycles originally depicting scenes from the lives of Saint Catherine and Saint

Benedict were originally located in the upper galleries of the Basilica and were detached into 22 panels in 1856 during the restoration works carried out by Pope Pius IX (1846–1878). The Saint Catherine cycle was found in the northern gallery extending on the area above the narthex while the Saint Benedict stories on the southern side of the matroneum. At present, they are preserved in the deposits of the Pinacoteca Vaticana and inside the Pope's personal apartments at the Vatican and are not visible to the public. By studying 16th century chronicles of the Basilica, measuring surviving medieval fragments of the original *schola cantorum* and combining these to the information provided by 13th century inscription we started tracing the medieval layout of Sant'Agnese during the 1250s.

3D Model and Technological Pipeline

The project pipeline was defined by Professor Marco Canciani, director of the Rilttec Laboratory

⁸ Pompeo Ugonio, *Theatrum Urbis Romae*, 1594, Biblioteca Comunale Ariostea di Ferrara, Classe I. 161, fol. 966 (transcription Santi Pesarini, *Appunti copie, estratti e schede riguardanti in massima parte le*

chiese di Roma, BAV, Vat. lat. 13127, fol. 458r); Claussen 2002, p. 65.

⁹ No surviving example exists in Rome dating to this period, but we know of several examples through sixteenth-century

chronicles, namely those of S. Bartolomeo all'Isola, S. Maria in Trastevere, and S. Saba; Claussen 2002, p. 58.



Figure 6
Sant'Agnese fuori le mura, 3D model of the interior.



Figure 7
Sant'Agnese fuori le mura, 3D model, longitudinal section.

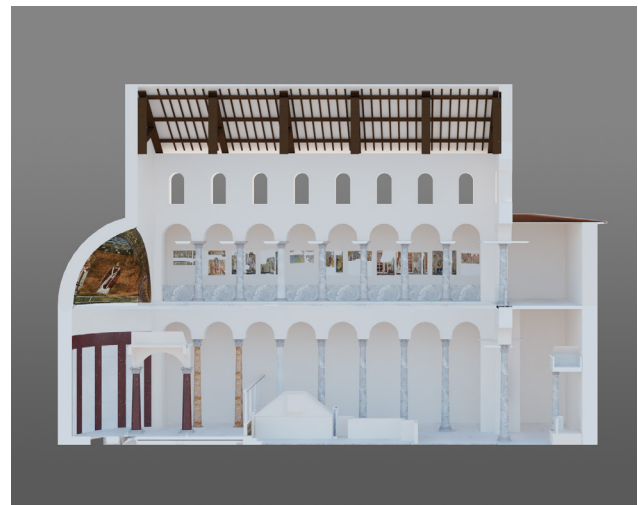


Figure 8
Sant'Agnese fuori le mura, 3D model, longitudinal section.

at the Department of Architecture of the Università degli Studi di Roma Tre. This laboratory aims to study and experiment methods relating to three areas in particular, which range from surveys of archaeological, architectural, urban and environmental heritage through 3D systems to multimedia communication through innovative methodologies (such as virtual anastylosis, augmented reality, etc.). While our aim is to create a three-dimensional model of the entire complex, we decided to start the process of reconstruction from the Basilica and work our way towards the other parts of the convent. The historical-documentary information was integrated with the planimetric surveys of the complex conducted by Dr. Emanuele Gambuti, who scanned the convent and outlined the architectural plans of the monastery for his PhD dissertation at the Department of History,

Representation and Restoration of Architecture at La Sapienza Università di Roma.¹⁰ The technological pipeline envisaged as a first step the creation of an orthophoto superimposed on the floor plans together with the cadastral classification drawn by the City Municipality (ca. 2010). Prior to the laser campaign inside the Basilica we took a series of measurements of the monastic complex to test the accuracy of Dr. Gambuti's plans. In December 2019 the laser survey was carried out by Professor Marco Canciani and Giuseppe Fioravanti with a Faro Focus instrument both in the church, in the monumental staircase, and in front of the façade. The point cloud was cleaned, and its alignment optimized with the program ReCap. In parallel we simplified Dr. Gambuti's DWG files in AutoCAD to obtain a rendering that was as close as possible to the original aspect of the

¹⁰ Gambuti 2019.

Figure 9
Sant'Agnese fuori le mura, 3D model,
screenshot from video <https://doi.org/10.17617/3.UCZKF4>



medieval church.¹¹ We used a 16th century plan of the complex (ca. 1550s) drawn by Alberto Alberti (1525–1598) as a visual map for the CAD drawings which were naturally integrated with the studies on liturgical furnishings conducted by Peter Cornelius Claussen in the *Corpus Cosmatorum*, and primary documentary sources mentioned above. Precise measurements of the surviving sculptural fragments were taken at Sant'Agnese to delimit the length and width of the choir enclosure. I then proceeded to measure Cosmati pulpits which shared a similar chronology to the one present at Sant'Agnese fuori le mura. This was executed at San Clemente, San Lorenzo fuori le mura, and Santa Maria in Cosmedin to create model prototypes for the virtual reconstruction of the *schola cantorum* at Sant'Agnese. We then proceeded to the 3D modeling *in vivo*, taking the point cloud as a reference point. The plans and elevations were modeled in 3D with SketchUp and Rhino and once the modeling was finished we worked with V-ray and Photoshop for the light and final touches in the rendering (fig. 6, fig. 7, fig. 8).

All measurements in the model are exact and account both for the sculptural fragments

present in nunnery, the point cloud, Gambuti's DWG file and Alberti's map. As far as the mosaic pavement is considered, for the video (fig. 9) we drew the one present in the model using the mosaic pattern at San Clemente as a benchmark. On a final technical note, the pictorial fragments were opened in photoshop – cut and reapplied as materials; while the PNG files did not work due to their transparency, we used them as standard JPEGS. Following Giulia Bordi's research on early medieval frescoes in Domenico Bartolini's writings, a provisional location to the fresco of the *Holy Princesses*, was allocated in the pillars of the narthex.¹² Finally, the detached frescoes at the Vatican were positioned inside the upper galleries of the Basilica following the narrative cycles of the *Saint Catherine* – *Saint Benedict* legends. The paintings have been temporarily positioned in the galleries in their fragmented nature, the next step will be to try and integrate the missing parts in a process of virtual integration. The video inside the 3D model was made using Premier Pro 30 which generated 30 frames per second creating a series of renders from the 3D model and file folders which were subsequently joined to create the video.

¹¹ Gambuti 2020, p. 125; Forni 1991.

¹² Bordi 2006, pp. 63–64; Frutaz 1960, pp. 164–165.

Conclusions

While the material presented in this article is still a work in progress, it bears witness to a methodological approach which combines architectural, archival, art historical research integrated with technical tools to aid visualization of research results. It is now apparent how the use of CAD technologies has revolutionized our critical engagement with the visual arts. IT-assisted research has dramatically changed the way we communicate the history of art and architecture. It is by recording the passage of time that these models acquire their significance, practically making them time machines, useful tools for researchers and the public at large. These 3D models set in motion a series of methodological and ontological issues which question all aspects of art history and force us to engage with new agendas for research. While the sustainability of Digital Humanities research is at the forefront of current debates, we should take a step back and ask ourselves what is the use of these models? How can we certify a best practice standard which balances out the need for accuracy with the aesthetic

quality of the object itself? It is through sound research of primary sources and transparent integration of technology that this may be guaranteed. While the peer review process in place in many academic journals has been heavily criticized, this could verify that these models have a certain level of accuracy which would ultimately foster a longer shelf life. Along with the actual feasibility of direct access we should also imagine new forms of publication, while ensuring copyright these should take into account the possibility of updating both software and content. Additionally, the fact that models are seldom successfully deployed in the classroom speaks to a limitation which is not only caused by an intrinsic design obsolescence characteristic of all technology, but also to a certain reticence on the part of the teaching body. In order to safeguard its survival through time, any digital [re]construction should take into consideration a pedagogical element, ultimately guaranteed through a thorough methodological research question. These models need to be live, open and discoverable and understood not as research products but as a research tool.

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Abstract

Giulia Bordi

Visualizing Medieval Rome. Digital Storytelling about the City and its Churches

keywords – 3D models, Virtual Reality, Medieval artistic heritage, Atlas, EHEM project



Since 2006, we have embraced the challenge to recontextualize and visualize wall paintings, mosaics, and panel paintings in medieval Rome's sacred buildings with digital technologies. We started with the project Atlas. Visual paths, setting paintings in space, rejoining them visually with architecture through plans and 3D digital models. We continued with the Santa Maria Antiqua Exhibition (2016–2021) experimenting with a multimedia path marked by video mapping, light mapping and videos aimed at displaying the history and complexity of the pictorial phases of the monument to a wider audience. 2020 marked the start of a new venture – EHEM (Enhancement of Heritage Experiences: The Middle Ages. Digital Layered Models of Architecture and Mural Paintings over Time). This is a three-year project, managed by a consortium of the Universities of Barcelona, Roma Tre, Tuscia (Viterbo) and the CYENS (Cyprus), and funded by EU Horizon 2020 (JPICH-0127). The project aims to obtain virtual reconstructions of medieval artistic heritage – architecture with mural paintings – over the centuries incorporating art historical knowledge and the diachronic perspective of heritage, as an instrument for researchers, restorers, and heritage curators and to improve the visitor's perceptions and experiences.

DOI: [10.48431/hsah.0205](https://doi.org/10.48431/hsah.0205)

Visualizing Medieval Rome. Digital Storytelling about the City and its Churches

Giulia Bordi

My interest in the world of 2D and 3D digital reconstructions began in 2004, when I started working on the project *Corpus and Atlas of Medieval Painting in Rome* (313 to 1431).¹ The *Atlas. Visual Paths* was designed by Maria Andaloro who challenged a group of her PhD students to find ways to reposition medieval Roman paintings – often reduced to fragments – within their context.² This entailed visually reuniting them to the architectural elements for which they were originally conceived (fig. 1). The *Atlas* was born with the specific goal of recontextualizing wall paintings, mosaics and panel paintings in Rome's sacred buildings, following a topographical order articulated on two levels: the topographic location of the monument within the city, organized in its historic districts, and its spaces. The *Atlas* was developed over eleven years through the use of plans and sections together with 2D and 3D digital models.³

In synthesis, the *Atlas*:

- virtually relocates the detached paintings onto their original walls;
- displays decorations that have since disappeared, but are documented by drawings, watercolors and engravings;
- magnifies the decorations, now reduced to fragments, inside their original architectural contexts, despite their having been modified over the centuries;
- showcases the different chronological decorative phases on a wall.

The *Atlas*, therefore, allows us to visually re-read pictorial documents within an integrated system.

Our aim was not to advance ideal or evocative reconstructions, but to create 2D and 3D graphic elaborations designed to emphasize the link between the wall paintings and the architectural contexts as they were originally designed.

We started from a 3D model derived from the direct survey of the architectural structures (at first using a total station and subsequently a 3D surface point cloud).⁴ When the monuments were destroyed or significantly modified by subsequent interventions, we used indirect surveys on the basis of historical documentation, rebuilding exclusively the internal space of the churches.

Onto the latter we then added images of:

1. existing paintings;
2. detached paintings;
3. drawings, watercolors or engravings in the case of lost artifacts.

These reconstructions were originally conceived for printed volumes, but this is only the first step of many, which aim to visually transmit Rome's medieval heritage to a wider audience, using mainly the Web. We now aim to integrate 2D and 3D reconstructions with visual and textual content in a specific geolocated digital environment. Our intention is to offer visual paths through which diverse audiences can enjoy the paintings of the Roman Middle Ages within their original architecture in and around the city. The aim for the near future is to join a digital platform such as DynASK–Dynamic Atlas of knowledge developed in the Department of Architecture of the Roma Tre University (scientific coordinator: Antonio Pugliano). This digital

1 The project was created and directed by Maria Andaloro (Tuscia University of Viterbo) and Serena Romano (Université de Lausanne).

2 Andaloro 2006a; Andaloro/Bordi/Viscontini forthcoming.

3 Bordi 2018, pp. 61–67.

4 The survey was carried out by Pasquale Tunzi and Pierpaolo Palka from the Gabriele d'Annunzio University of Chieti and Integra Software e rilievi s.r.l and then by Marco Carpicci and his team from the Engineering

Department at La Sapienza University (Rome). Arch. Gianni di Benedetto was instead responsible for the graphic and modeling of the renders.

Figure 1
Rome, St Paul Outside the Walls, nave, south wall, 3D model.
Photo: Andaloro 2006a.

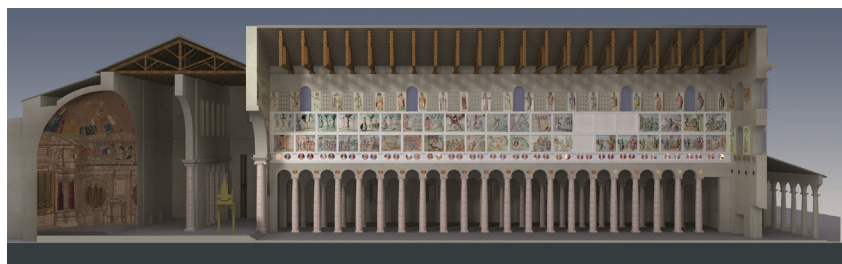
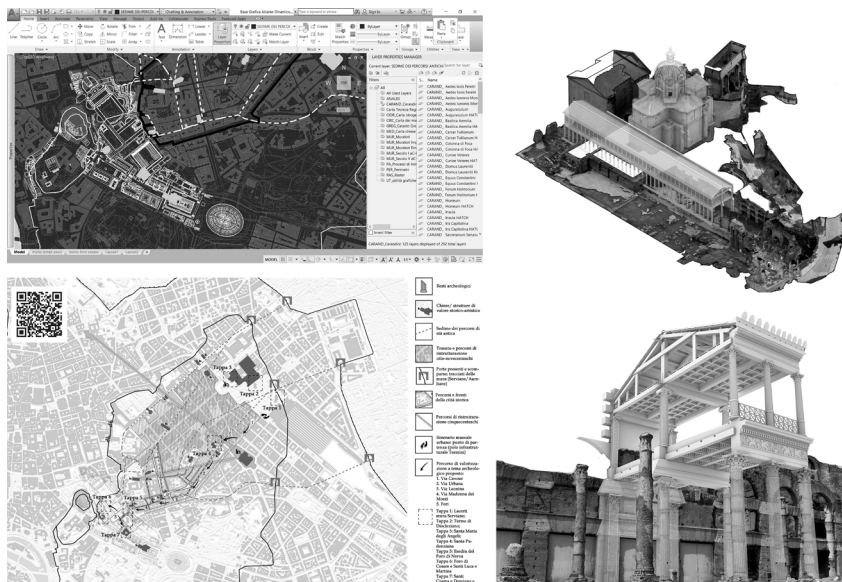


Figure 2
DynAsk project: a) Rome, archaeological central area, geographical DB; b) example of an urban itinerary in the central area of the city; c-d) Archaeological central area, 3D models of lost buildings.
Developed by Marco Piccoli and Max Vita, in Pugliano 2021.



information system on a geographical basis aimed at deepening the knowledge of Rome and its Metropolitan Area by protecting the urban fabric from exploitation while at the same time forecasting seismic and hydrogeological risks.⁵ The platform already comprises several cartographies of Rome ranging from the *Forma Urbis* to Nolli's map, from the Gregorian Land Registry, to both Lanciani's and Muratori's maps. All geographical and historic information are collected in a database both textual and graphic; the information in the GeoAI system is redrawn in AutoCAD and implemented into a GIS. At the moment the system manages over two thousand thematic information layers.⁶ In this frame, our 3D models of churches (from 4th to 15th century) will be linked to the maps of medieval Rome, such as Muratori's, which, in the future, will allow the larger audience to explore the city and discover its pictorial treasures (fig. 2).

Santa Maria Antiqua Exhibition

To this end, the 2016 exhibition *Santa Maria Antiqua. Between Rome and Byzantium*, was a crucial test for us. The exhibition was curated by Maria Andaloro, Giuseppe Morganti and me on the occasion of the extraordinary reopening of the church after a restoration phase which lasted fifteen years.⁷ The church of S. Maria Antiqua at the Roman Forum was discovered in 1900 on the west slope of the Palatine Hill. Its surviving wall paintings represent a unique heritage in the Christian world between the 6th and 10th centuries. The pictorial decoration testifies to the development in the Middle Ages of both painting in Rome, and – due to the destruction brought upon sacred images by Iconoclasm – that of the entire Byzantine civilization.⁸ The 'palimpsest wall', considered by many scholars a milestone in the history of medieval

⁵ The project is presented in detail in a recent volume edited by Pugliano 2021.

⁶ Pugliano 2021, pp. 19–32.

⁷ Andaloro/Bordi/Morganti 2016.

⁸ See now the volume: Rubery/Bordi/Osborne 2021.

Figure 3
Rome, Santa Maria Antiqua: a) interior; b) the
'palimpsest wall'.
Photo: Gaetano Alfano.



Figure 4
Still frame from the film projected on the
video wall in Santa Maria Antiqua. Virtual
restoration of the sanctuary wall paintings.
© Katatexilux



painting, bears witness to the development of the decorative phases of the church through the overlapping of eight layers of murals (fig. 3).⁹

The exhibition exposed to a wider audience a multimedia path marked by video mapping and light mapping, used for the first time in the Roman Forum, alongside videos aimed at displaying, through an emotional journey, the history and complexity of the pictorial phases of the monument. The *Santa Maria Antiqua* video, projected inside the monument on a video wall, allowed one to browse, with the aid of dynamic images, the extraordinary pictorial palimpsest preserved on the apse wall of the church and to follow, by means of virtual reconstructions, the metamorphoses undergone by the pictorial decoration on the walls of the monument over five centuries (fig. 4).¹⁰

After a long and often painstaking physical restoration of the frescoes, a virtual restoration

was used. This enabled the general public to 'read' the iconographic fabric in its entirety, as opposed to its fragmented surviving state. Based on the 3D reconstructions proposed in the *Atlas*, the video mapping, then, allowed to project – with an immersive approach – directly onto the walls of the chapels on the sides of the presbytery, the complete pictorial fabric as well as the decoration in opus sectile. The projection started with a line-drawing and finished with a complete virtual restoration of the painted decoration (fig. 5).¹¹ The installation was enormously successful and is still open to the public as part of the special route offered to visitors of the Archaeological Park of the Colosseum. The exhibition was conceived as a temporary installation, but became a permanent attraction. This will require a review in the short term, giving the opportunity to reflect in greater detail around the necessity of tailoring and creating bespoke experiences for different and often diverse users.

⁹ Bordi 2021, pp. 387–422.

¹⁰ Bordi 2018, pp. 67–68.

¹¹ Immersive reality and video narrative developed with Progetto Katatexilux. [https://](https://www.katatexilux.com)

www.katatexilux.com (26/09/2021).

Figure 5
Rome, Santa Maria Antiqua. Chapel of
Theodotus, video mapping of the lost opus
sectile decoration.
© Katatexilux



EHEM Project

With this new problem in mind we took part in the project called EHEM,¹² *Enhancement of Heritage Experiences: the Middle Ages. Digital Layered Models of Architecture and Mural Paintings over Time*, funded by EU Horizon 2020, JPI CH Conservation, Protection and Use (JPICH-0127).¹³

EHEM is a three-year project, managed by a consortium of the Universities of: Barcelona,¹⁴ Roma Tre,¹⁵ Tuscia (Viterbo),¹⁶ and the CYENS Center of Cyprus.¹⁷ The EHEM team comprises art historians, CS engineers, restorers, and scientists.¹⁸

The project aims to obtain virtual reconstructions of medieval artistic heritage — architecture with mural paintings — over the centuries by incorporating art historical knowledge and the diachronic perspective of heritage, as an instrument for researchers, restorers and heritage curators and to improve the visitor's perceptions and experiences.

In the 3D models elaborated we intend:

1. To reach a real understanding of the construction of a building and its structural “anomalies”.
2. To solve chromatic problems. This will allow us to obtain digital reproductions

that are as close as possible to the originals and distinguish them from the restoration campaigns.

3. To raise and advance a resolution tied to the original lighting of these complexes. Improve the analysis of natural lighting, and deal with artificial lighting by chandeliers or oil lamps, which produced effects of painting vibration at the moment when, for liturgical reasons, the images get activated.
4. To digitally approach the different perspectives of the medieval building and their paintings according to the categories of users (namely the laity and clergy).

We selected three case studies:

- Santa Maria Antiqua in the Roman Forum (Rome, Italy);
- The hermitage of St Quirze de Pedret in Catalonia (Spain). This site has a complex architectural genesis with paintings ranging from the 10th to the 12th centuries. The major part of them was detached and transferred to the MNAC (Museu Nacional d'Art de Catalunya – Barcelona) and the MDCS (Museu Diocesà i Comarcal de Solsona) in 1921 and 1937 (fig. 6).¹⁹
- The Engleistra of Agios Neophytos Monastery in Paphos (Cyprus), an oratory half built in

¹² Ehem in Latin means: Oh! Look!

¹³ <https://www.heritageresearch-hub.eu/homepage/heritage-projects/>.

¹⁴ PI Milagros Guardia Pons, she is also the

Project leader.

¹⁵ PI Giulia Bordi.

¹⁶ PI Paola Pogliani.

¹⁷ PI Panayiotis Charalambous.

¹⁸ <https://www.ehemproject.com>.

¹⁹ See Cayuela Vellido 2022.

Figure 6

Catalunya, St Quirze de Pedret: a) interior of the church without wall-paintings; b) Museu Diocesà I Comarcal de Solsona, wall-paintings detached.
© Katatexilux.



Figure 7

Paphos, The Engleistra of Agios Neophytos Monastery: a) exterior; b) interior, wall-paintings.
Photo: Carles Mancho.



stone and half excavated in the rock comprising up to five decorative phases executed from the 12th century (fig. 7).²⁰

By working at the same time on the three monuments we will be able to understand the benefits and limitations of adopting an ontology that drives workflows and standardizes methods.

In relation to Santa Maria Antiqua, one of the aims of the project is to display and showcase each and every phase tied to the ten layers of fresco that we mapped inside the church. We will create 3D digital models that incorporate this information in layers in the form of a database that allows us to collect archaeological, architectural, art historical documentation, textual and graphic data, together with the current state of knowledge on the site. According to the EHEM approach, the lifecycle of the building will be digitally reproduced in all its temporal phases, like a time machine. Layer upon layer we want to piece together the pictorial decoration of the church through its iconography.

The 3D model will also incorporate information on the different materials and techniques linked

to the ten pictorial phases gathered in more than fifteen years of surveys and restoration campaigns.

EHEM Methodology

The project is structured into four blocks (fig. 8). Block 1 specifies the actions required to acquire the data and associated information of the temple; Block 2 embraces the different research activities that deal with generating the faithful and complete models; Block 3 consists in storing and enriching the models in a common open access platform; Block 4 is about making results available to different users. We organized the project into nine work packages (fig. 9). WP3–7 refer to scientific activities; the others are functional: for example, management (WP1); specifications (WP2); evaluation (WP8); and dissemination (WP9).²¹ WP3 encompasses the tasks from the acquisition of images, to the placement of the paintings onto the digital model of the building.²² These tasks include: acquisition of faithful color specification using a Hypercolorimetric Multispectral Imaging (HMI) technique;²³ digital color restitution; virtual restoration of murals; collection within

²⁰ <https://vimeo.com/538552468> (26/09/2021). See Mango/Hawkins 1966, Paschali/Minasidis 2023.

²¹ Guardia *et al.* 2021, pp. 40–41.

²² In WP3, in order to improve image quality

we developed an acquisition protocol for photogrammetry, for the 3D survey and for the photographic campaigns to use the same parameters for visualizing the wall paintings of the three case studies.

²³ This approach was developed by Profilocore and set in the project by the team of DEIM Department of Tuscia University. See Ricci *et al.* 2021; <https://www.profilocolore.com/>.

Figure 8
EHM project: Conceptual research structure.

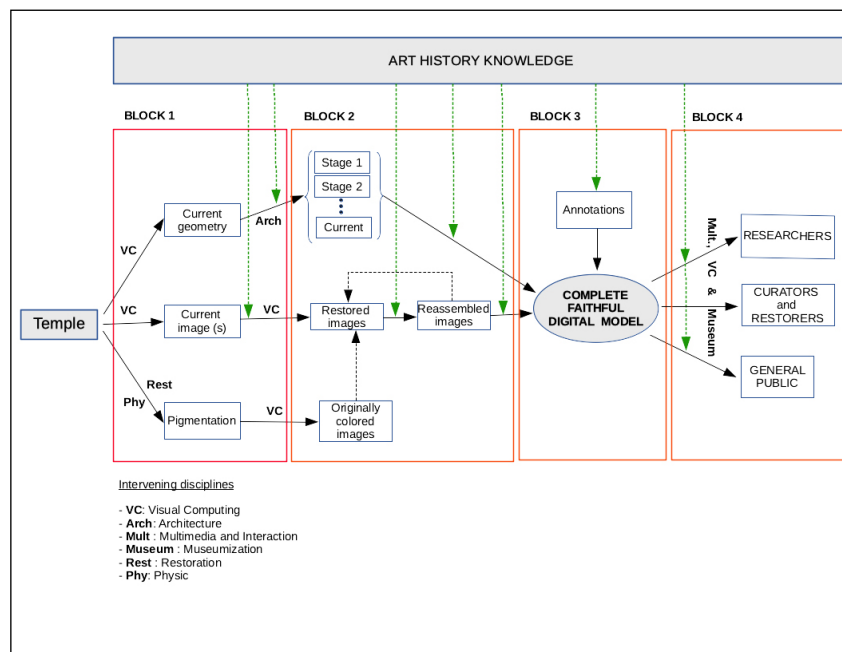
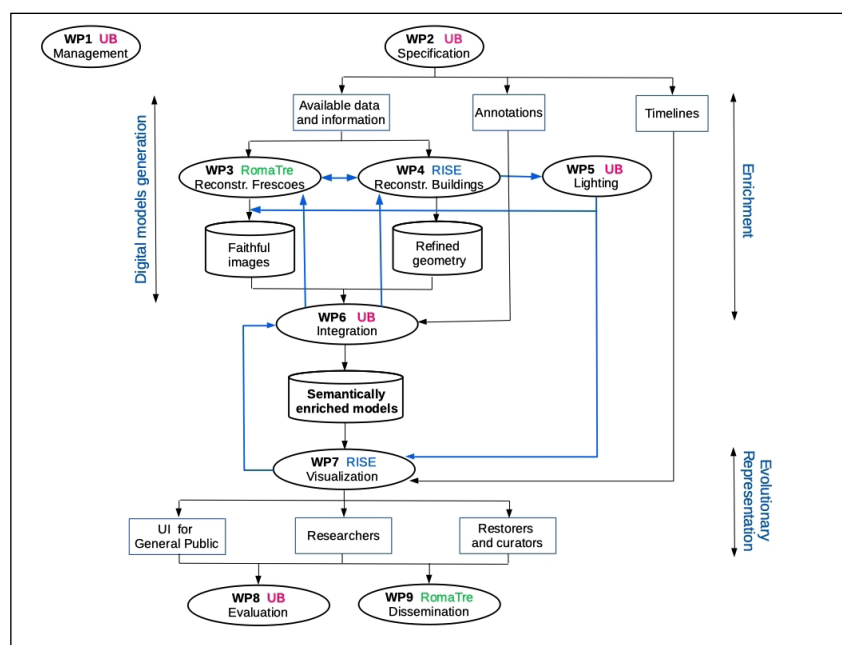


Figure 9
EHM project: Work packages scheme.



the digital model of the detached paintings stored in different locations. WP4 foresees the digitization of buildings and their geometric processing in order to obtain a mesh adapted to the needs of the project (intended to interact with WP3).²⁴ WP5 involves providing the simulation of the lighting suited to each period and to associate it with distinct visualization phases (WP7). It includes natural lighting through openings, simulated according to weather

conditions and seasons, and artificial lighting produced by different sources such as candles and oil lamps. To simulate the lighting, Unreal Engine 5, a modern, high-performance game engine in combination with Radiance (lighting simulation tool) and Lumen (lighting software by Epic Games) are being used in the 3D models of each site.²⁵ WP6 concentrates on storing in an adequate platform that enables one to analyze, document, share and enrich the

²⁴ Concerning WP4, in St Quirze de Pedret, MNAC, MDCS and Santa Maria Antiqua laser survey was carried out by the team of Virvig - Research Center for Visualization,

Virtual Reality and Graphics Interaction (Universitat de Girona, Universitat politècnica de Catalunya, Universitat de Vic) using a LIDAR scan (Leica RTC360) combined with

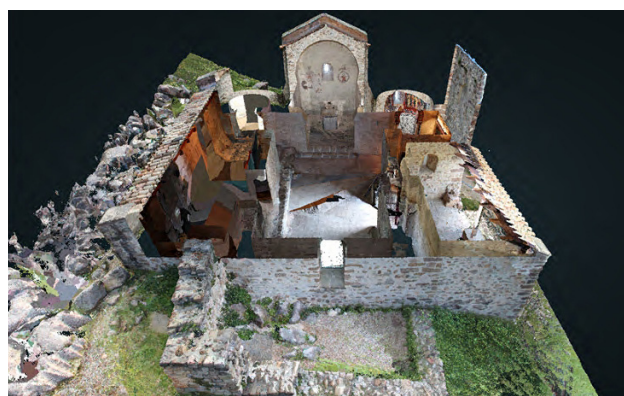
photogrammetry; the Enkleistra was done exclusively with photogrammetry. Munoz-Pandiella et al. 2022.

²⁵ See Munoz-Pandiella et al. 2022, par. III.A.4



Figure 10
HMI acquisition carried out in the Museu Diocesà i Comarcal de Solsona. Photo: CYENS Photo Archive.

Figure 11a-11b
Inspection of St Quirze de Pedret pointcloud.
© Katatexilux



models produced by WP3 and WP4. We foresee to annotate the models. For annotations requiring simple regions, we plan to use the Annotorious JavaScript library, as far as targets with complex boundaries, we have developed a tool prototype (based on TagLab).²⁶ WP6 will provide feedback to WP3 and WP4. WP7 is intended to present the results to the different targeted users (general public; CH restorers and curators, the academic community) designing and implementing the suited GUI to each community, guided by the evolutionary approach of the project.²⁷ WP7 provides feedback to WP6.

Conclusions

I would like to conclude with a reflection that occurred to me while observing the visitors at Santa Maria Antiqua and which touches on our anxiety to produce 3D models that are increasingly realistic and seductive from an aesthetic

point of view. In the Theodotus chapel spectators enter, watch the video mapping and leave without dwelling on what is really painted on the walls. A few months ago, I read a small but illuminating book entitled *Bassa risoluzione* (Low resolution) by Massimo Mantellini, a leading expert on the Italian Internet network.²⁸ Mantellini states that although we live in an era of high resolution, low-resolution contents are passed off to the audience. The Internet has radically changed our approach to depth, information, social relations, markets and culture. Therefore, the choice of low resolution is a choice of reduction, a renunciation of complexity. Working on the virtual restitution and storytelling of contexts found in medieval wall paintings, which are almost always fragmentary and difficult to understand, I wonder if the real cultural challenge that awaits us is, paradoxically, that of using all available technology to activate the general public's imagination. In

²⁶ See Munoz-Pandiella et al. 2022, Barreiro Díaz et al. 2022.

²⁷ For point cloud models, a web application based on Potree has already been realised that allows the model to be inspected, clipping planes to be used and

measurements to be taken (see Munoz-Pandiella et al. 2022). For 3D mesh models, on the other hand, a VR prototype has been developed, based on an extension of the client-server system PhotoCloud, which allows the user to explore both the model

and image sets at the same time (see Farràs/Comino/Andujar 2021).

²⁸ Mantellini 2018.

this manner, we might seek out tools that help them read history, contexts, and, in my specific field, architecture with paintings in their fragmented and complex nature, and thus we would forgo presenting them with depictions that are intact and mimetically restored in a virtual world.

I believe that elaborating high-resolution, realistic 3D models is more useful to the academic community, than for the public. The latter are likely to experience the models as spectators, and often they passively take in our visualizations of a monument without stimulating their imagination of how it could have been in the past.

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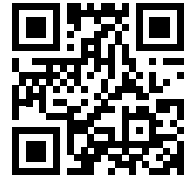
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Abstract

Nicola Camerlenghi

Virtual St. Paul's Basilica 2.0. Developing an Open Educational Resource

keywords – Rome, Open Education Resource, Virtual Reality, Digital Modeling, St. Paul's Basilica



Rome's fourth-century Basilica of St. Paul's Outside the Walls, which burned down in 1823 and was then rebuilt, is the principal cult center of the Apostle Paul. Despite its travails, the building is well documented in graphic, written and archeological sources, which together provide sufficient data to build digital models of the building over time. These models were the backbone to a published monograph and associated website. My current aim is to develop a diachronic, virtual reality experience available to a broad audience of students and scholars—an endeavor that presents an opportunity to focus on issues critical to both our discipline and its pedagogy. Digital reconstructions seldom address the importance of scientific transparency to the evaluation of the work in a structured, documented, and peer-reviewed manner. Regarding pedagogy, a major challenge is the creation of an experience that can be easily and reliably employed in diverse learning environments. I aim to address both shortcomings, by augmenting my digital model of St. Paul's with interactive annotations that permit users to select features in the model to (1) learn about them; (2) call up primary sources used in their reconstruction; (3) understand the process by which data were interpreted; and (4) verify accuracy. In sum, the project is a testing ground to formulate best practices for content delivery that will enhance embodied experiences, exploratory learning, and architectural education within virtual spaces.

Doi: [10.48431/hsah.0206](https://doi.org/10.48431/hsah.0206)

Virtual St. Paul's Basilica 2.0. Developing an Open Educational Resource

Nicola Camerlenghi

The Basilica and the History of the Virtual Basilica Project

The Basilica of St. Paul in Rome, originally constructed in the fourth century, was one of the oldest standing churches in the world until a fateful fire reduced it to rubble in 1823. Lost in that conflagration was the last imperial basilica built in Rome, the city's second largest church, and the global epicenter for the veneration of St. Paul. Through the centuries, the building—like its namesake—had become a protagonist in the development of Christianity and, thus, serves as an exemplary case for the study of ecclesiastical architecture, writ large. Also lost to—or at least greatly compromised by—the fire was our ability to know and study the building's complex evolution. A similar fate befell countless works of art housed within, while those that survived lost their original context. Today, following its nineteenth-century reconstruction, the basilica stands as a UNESCO World Heritage Monument and continues to attract many pilgrims, tourists, and scholars.

Yet another kind of reconstruction of St. Paul's is possible and currently underway. Since 2012, I have been engaged in the digital modeling of the basilica across its long history. Initially, the model allowed me to make sense of the various transformations that took place there. The ability to conduct the necessary back-and-forth between visualization and analysis is taken for granted with buildings that still stand; but that operation is considerably more challenging for buildings, like St. Paul's, that are no longer extant. The digital model allowed me to understand the complexities of the building that perished in the flames. That initial phase of work culminated in a book—*St. Paul's Outside*

the Walls: A Roman Basilica, from Antiquity to the Modern Era (2018)—and a website that hosts, among other assets, a proof of concept Virtual Reality walkthrough experience (version 1.0) of the building on the eve of the fire.¹ Since its commencement over ten years ago, the Virtual Basilica Project has undergone various changes with respect to technology, output, and even purpose. This short contribution treats the new goals and opportunities inherent to broadening the focus and reach of the project's second iteration.

Now, with funding from an NEH–Mellon Digital Publications grant and support from Dartmouth College's Data Experiences and Visualizations Studio and collaboration from Smith College's Imaging Center, the project is becoming an intuitive, interactive, annotated, diachronic, Virtual Reality (VR) model of St. Paul's Basilica for students, scholars, teachers, tourists, and others interested in the history of Rome and of Christianity. Through three basic modes (“tour”, “exhibition”, and “exploration”—outlined below) users will be able to tailor their experience of the virtual building. Users are able to move through space—a handy plan is provided—and through time—seven periods are selectable through an interactive timeline (see video <https://doi.org/10.17617/3.N7FNCA>). From our perspective as developers, the project is an opportunity to create and share knowledge through a custom-built user interface. Along the way, learning opportunities abound for myself and the rest of the development team. If this present written contribution reads like a proposal that is because the project is not yet complete. But even in its incomplete state, it presents the chance to address the nature and value of Virtual Reality.

¹ Camerlenghi 2018. For the website:
<https://rcweb.dartmouth.edu/CamerlenghiN/>

VirtualBasilica/index.php or also <http://dartgo.org/virtualbasilica>.

The Digital Model in Virtual Reality

In academia and heritage conservation, the role of digital models—particularly those experienced through VR—is being constantly redefined. A key reason why VR has yet to claim a pivotal place in the humanities (and elsewhere), in part due to equipment and production costs. But dropping prices and enthusiastic developers suggest that in a handful of years those challenges could be overcome. Now is the time to shape the medium into a useful and intuitive supplement to conventional modes of visualization and analysis for humanistic study. As I write, big tech has launched an overt effort (to wit, the “metaverse”) to direct the future of the medium. In academic circles, VR projects are still rather niche and find outlets in books and journals often as still frames, but increasingly they are being shared with more of their complexity intact thanks to electronic publications such as this one. In conservation and cultural heritage circles, VR models play a role in documentation, conservation, and valorization. Often, actual usage of the models (through VR headsets or through AR-enabled hand-held devices) is limited to the site in question. One thinks of the projections that are part of tours at the Palazzo Valentini or the augmentations of the Domus Aurea, to mention just two examples in Rome.² The Virtual Basilica Project, 2.0 hopes to encompass a variety of circles—from academic and heritage, to religious and cultural ones—and it does not require one to be physically present on site.

The project builds upon and expands the features present in several existing digital reconstruction projects related to other buildings. In the classroom, an instructor will be able to impart lessons as if on site. The recent pandemic has reminded even the most fortunate not to take travel for granted, an opportunity the less fortunate are seldom able to have. All this is more reason to foster virtual experiences, not as

substitutes for, but as *complements* to the physical world. The simulation of being “on-site” is an aim shared by other VR evocations of cultural spaces such as the Sistine Chapel; but, unlike that project, focused on celebrated surface decorations, the virtual basilica presents decorative, architectural, and archaeological details across time.³ Like another groundbreaking project, Rome Reborn, users will be able to juxtapose historical reconstructions with a representation of the current site.⁴ The project will contrast not just antiquity and the present, but select moments from across the history of the basilica. My reconstructions have been based on a careful study of archaeological reports, written descriptions, and over 1,700 images including detailed survey drawings. Such dependence on and respect for primary sources is modeled on projects like Visualizing Venice, a pioneering research platform, which presently lacks a VR component.⁵ In order to share both the primary evidence and its interpretation, a system of annotations—inspired by commercial pedagogic softwares like Organon’s VR Anatomy—can be activated by clicking hotspots located at key points around the virtual building (see fig. 1).⁶ These annotations will be important features of the project and include didactic text, images, audio, and/or video.

Movement and its Challenges

The ability to move in (and to interact with) a model like the Virtual Basilica Project unleashes important affordances. Decisions about what movement to invite revolved around two factors. The first approach aimed to convey the experience of the space. In this case, the observer of the model—often called the “user” in digital parlance—needs phenomenological veracity, which includes a relatable speed of movement, eye-level perspective, and lack of distortion in the rendering of the space. The second approach to movement in virtual space aims to enable analyses impossible in the physical world. In this case, the user, no

2 For Palazzo Valentini, see: <https://www.palazzovalentini.it/domus-romane/index-en.html#visita>. For the Domus Aurea, see: <https://parcocolosseo.it/en/guided-tours/domus-aurea-experience/>.

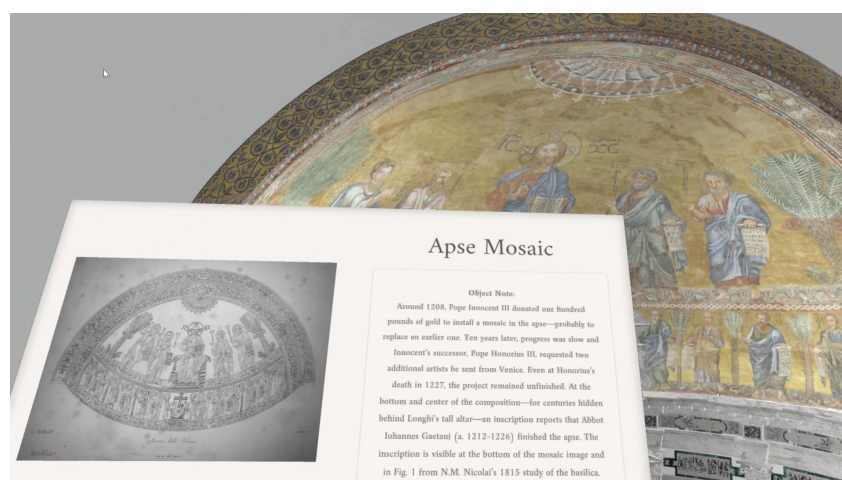
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6 https://store.steampowered.com/app/548010/3D_Organon_VR_Anatomy_2018/.

Figure 1
The apse with annotations.
Image by the Author.



longer gravity-bound can “fly” around to access hard to reach areas or details, to see through or within walls or floors to explore hidden features and their relation to visible ones. This movement lacks a phenomenological counterpart in the physical world; indeed, it is a hyper-physical, extra-corporeal sort of experience.

For each of these movement types, we envisioned an over-arching category of user. The gravity-bound mode that demands phenomenological veracity might best apply to the history buff, amateur, pilgrim, or tourist. After all, such movements are generally not jarring and yield easily conveyed takeaways. The second category of user might be the scholar, who wishes to test hypotheses, see through surfaces, even measure, or vet dimensions with our virtual measuring tape. The freedom inherent to hyper-physical movements within a model is less compelling to a broader public. In the end, both options needed to be offered to accommodate the breadth of possible users.⁷

In theory, the ideal manner to experience a digital model would be through unrestrained movements, where the user is allowed to explore from any angle or position. In practice, however, this sort of freedom comes at a cost. Simulator sickness (a form of motion sickness) increases hand in hand with such unrestrained forms of navigation, especially when the model is viewed with virtual reality visors. Indeed, both gender and generational challenges exist to the

experience of a model through VR navigation. Studies have shown variances in interpupillary distance (IPD) to be the major (preventable) factor, alongside the (less preventable) propensity for simulator sickness among females.⁸ And in terms of generational challenges, it has been shown that people with extensive (video) gaming experience can “train away” the motion sickness, but gaming remains a practice more common to younger generations. In terms of interface design, constrained visualizations that use “blindings” while in motion (see fig. 2) and forcing motion along pre-defined paths—a bit like visiting a museum exhibit, where one moves sequentially from room to room—are solutions that lessen simulator sickness.

The project is touted primarily as a VR experience but given the challenges to the medium we are developing an interface that functions with a regular monitor and through keyboard-controlled movements. Of course, the desktop screen sacrifices the phenomenological veracity and full immersion potential of virtual reality. With both interfaces, users will be able to walk among the rafters on the eve of the fire, fly by fifth-century frescoes, stand at the altars where popes celebrated Mass, examine the numerous sarcophagi beneath the floor, and crawl into the tomb believed to belong to Paul.

Unrestrained movement has another shortcoming. For the sorts of structures being modeled by historians, scholars, and those concerned with

⁷ Though still limited in its rendering capacity, a platform like Mozilla Hubs,

permits users to conduct a class or seminar in a virtually modeled space.

⁸ Stanney/Fidopiastis/Foster 2020; Grassini/Laumann 2020.

Figure 2
Screenshot of activated “blind-ers” to lessen simulator sickness.
Image by the Author.



cultural heritage, it is often not enough to merely convey a sense of space. It is desirable to also convey a sense of historical space. Perhaps counterintuitively, a user can acquire a more profound appreciation for the historical use of space, by being restricted in her or his movements. Freedoms and restraints to movement were—and in many cases still are—based on status. To reflect this principle within a digital model is to open interesting aspects to the study of historical space and historical movement. Consider that the presbyterial enclosure around the tomb of St. Paul was a space reserved solely for clergy. Our simulations of movement along with being phenomenologically accurate, are pitched to a user, who might virtually embody a pope, priest, prince, or pilgrim. The challenge became to design an interface that could negotiate the user experience in a compelling and intuitive manner. Intuitive interfaces have historically been the purview of the commercial gaming industry, from which scholars have much to learn.

Features of the Open Educational Resource

Thanks to these capabilities, the project is veering toward another category of digital media known as Open Education Resource (OER).⁹ OERS have yet to acquire the status of other digital outputs. In promotion and tenure terms, at least in American universities, with which

this author is familiar, they are demoted to the category of teaching, rather than recognized as potential instances of research.¹⁰ Indeed, most OERS combine both facets of an academic's job description. OERs need not be mere teaching tools showcased by an enterprising teacher, presented to a flipped classroom, or offered as an instance of experiential learning. Indeed, they can be as densely annotated as an article, as copiously illustrated as a lavish book, and as chalk-full of information and interpretation as any conventional form of academic publication. Having already produced a research-centered digital model that helped develop new visualizations, analyses, and hypotheses, I opted to transform it into a Virtual Reality and regular screen interface OER.

At the start of the experience, users will be introduced to the digital interface and to the building with audio and written explanations. They will be asked to choose between “tour”, “exhibition”, and “exploration” modes. In “tour” mode, one is guided through the building along a choice of pre-selected paths, each dedicated to a specific theme such as “Paul's Tomb through the Ages,” “Artworks within the Basilica,” “The Pilgrim's Basilica,” and “The Popes' Basilica.” The last two tours encourage users to learn through simulation (and virtual embodiment) about the distinct spatial experiences available to pilgrims and prelates at St. Paul's.

⁹ <https://www.oercommons.org/>.

¹⁰ <https://www.doers3.org/tenure-and-promotion.html>.

“Exhibition” mode assumes the user has become familiar with the interface and the building, which should occur upon completion of one or more guided tours. In this mode, one can travel to any of the tour stops and interrogate the building through 150+ interactive annotations accessed by directing a simulated laser pointer onto features in the virtual building. These annotations illustrate the basilica’s features and the process of their digital facture by engaging assets not available in “tour” mode, including a database of historic images. The ability to call upon digitized primary sources makes the project as much an interpretation of sources as a repository for them.

The final way to experience the building is in “exploration” mode, which enables free-range movement in space and time, while still providing access to the annotations. Additionally, by toggling a feature called “certainty vision,” which pinpoints objects whose location, material, or both remain uncertain, one can parse through vexed or unresolved aspects. In “exploration” mode, a user can question the benefits and limitations of the reconstruction by critically engaging, measuring, and verifying the model’s accuracy against the primary sources—an aspect essential to peer-review. The three interactive modes (“tour,” “exhibition,” and “exploration”) organize the digital experience for the viewer to best achieve the VR model’s potential as a broad-reaching, pedagogic, and scholarly tool.

Perhaps the most pedagogically innovative aspect is the fourth mode called “tour creation.” Here, a student or teacher is invited to design, assemble, and export their own tour set at a specific time in the basilica’s history, located in a specific place, and enlivened with an original audio component recorded by the user. The very tools that I, as developer, use to devise the stops of the “tour” mode, are the tools that a user can deploy to develop their own narrative or interpretation. The tours can then be saved and shared with peers, in a classroom setting, or even evaluated by a teacher or professor.

Output and Future Potential

Developed by importing 3Ds Max models into Unity, the Virtual Basilica Project will be made available through SteamVR and OER Commons and through the Basilica website mentioned above. Future funding could transform the VR model into an Augmented Reality (AR) experience, whereby visitors to the actual building could use their hand-held devices to call up reconstructions of earlier phases, view archaeological finds below the floor, and learn about these through annotations.

And beyond the current aims of the project, the digital models—those adopted to generate the OER—remain controlled environment through which to ask and test research questions about a range of subjects, such as acoustics, lighting, celestial alignment, etc. It is possible for a variety of scholars to ask different questions from these controlled environments. In other words, there is opportunity to embrace interdisciplinary themes that broaden the scope, applicability, and the affordances of the models. For this to work effectively, it is essential for the models to be placed in an open-share environment (in our case GitHub) and not to be siloed away. In this manner it can function as an open-ended and interoperable research tool, rather than a single-use product. The model of St. Paul’s, for example, can serve one scholar’s needs to study the circulation of people, and another scholar’s desire to consider how sunlight moves through that building, while a third scholar might examine that building’s relation to the broader urban or topographic setting. The same open-share environment will be adopted for the custom-made user interface. Its time travel capability, map interface, uncertainty mode, and annotations can easily be adopted by a third party interested in sharing their own digital reconstructions of another site. This represents a paradigm shift, because a model or user interface treated in this fashion becomes a non-linear, open and unfinished entity, unlike the journal article or monographs that scholars are generally trained to produce.¹¹

¹¹ See for example, Stabel 2014, especially p. 32.

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Abstract

Fabrizio Nevola, Donal Cooper, Chiara Capulli, Luca Brunke
Bringing Together Geospatial Information, 3D Modeling,
Experiential Learning and Research Data. The Ospedale
degli Innocenti: A Case Study of the Florence 4D Project



keywords – Digital art history, 3D models, CIDOC CRM
ontology, Ospedale degli Innocenti Florence, Geodata

Florence 4D draws on the principal spatial toolset for digital art history – 3D/Augmented Reality, GIS, and GPS-enabled mobile usage – to research works of art within their architectural and urban context, while ensuring access to underpinning evidence through a structured database. These approaches are brought together in Florence 4D's website, which allows researchers to explore material through a range of interfaces: maps, 3D models, locative AR apps and a database structured using the CIDOC CRM. Through guided navigation of the website, this short contribution considers a case study of the Ospedale degli Innocenti, Brunelleschi's famous foundlings' hospital, to demonstrate how digital tools can help us investigate the institution's footprint in the social and artistic life of Renaissance Florence at a variety of scales, from the wider urban context right down to individual decorative elements in the building interior.

Doi: 10.48431/hsah.0207

Bringing Together Geospatial Information, 3D Modeling, Experiential Learning and Research Data. The Ospedale degli Innocenti: A Case Study of the Florence 4D Project

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Introduction to the Florence 4D Project

Florence 4D adopts digital art history approaches to deliver a paradigm shift in how context-based research on art and architecture might be delivered through the integration of spatial methodologies, especially mapping and 3D visualization.¹ The project focuses on the well-studied city of Florence, to offer a new approach – drawing where possible on existing data – that favors diachronic histories over previously prevalent linear narratives. Our project workflow is reliant on a research-based modeling process, but creates interoperable data and visualizations, ensuring that our outputs address not only the research community in the university and museum sectors, but also the wider public.

Florence 4D draws on the principal spatial tool-set for digital art history – IIIF-enabled images, 3D/Augmented Reality, GIS, and GPS-enabled mobile usage – to research works of art within their architectural and urban context, while ensuring access to the underpinning evidence through a structured database. These approaches are brought together in Florence 4D's website, which allows researchers to explore the material through a range of interfaces: maps, 3D models, locative AR apps and the database where the research underpinning 3D reconstructions and the mapping layers is presented as structured data using CIDOC CRM triples. Through guided navigation of the website, this short contribution considers a case study of the Ospedale degli Innocenti, Brunelleschi's famous foundlings' hospital, to demonstrate how digital tools can

help us investigate the institution's footprint in the social and artistic life of Renaissance Florence at a variety of scales, from the wider urban context right down to individual decorative elements in the building interior.

Context in focus

The website landing page invites users to explore Florence through four main entry points: geospatial data plotted on historical maps, 3D models accessible via an online viewer built in Unity, locative mobile applications, and finally structured metadata.² The map interface (fig. 1) allows users to explore the data spatially at the widest urban scale, with a series of geo-datasets presented as points on a map which can be viewed in a variety of modes.³ An underlying Mapbox base-map and satellite view plots datapoints on the modern city, while georectified historic maps situate that same data on cartographic representations made in the late sixteenth and eighteenth centuries. In addition to datapoints the map also shows sites where we have conducted detailed building-scale research, rendered as small, colored 3D models that pop up on the map to invite further interaction. At this map scale, a number of datasets – city descriptions, censuses, pastoral visitations, artistic surveys – can be searched and filtered to reveal spatial relationships that research focused on specific case studies might not highlight.

The entry point to the maps presents a series of "Tours", curated datasets that are grouped thematically, to provide a degree of

¹ Florence4D project (www.florence4d.org) is led by Prof. Fabrizio Nevola (University of Exeter, UK) with Dr. Donal Cooper (University of Cambridge) and funded by the Getty

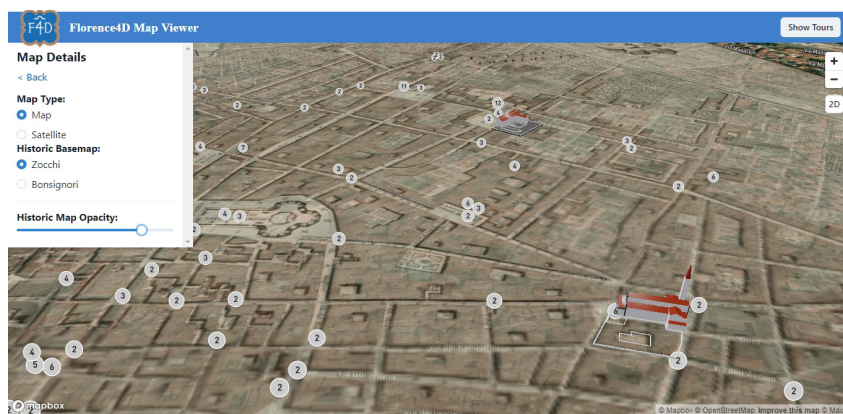
Foundation (2019–2021). All URLs in this article were accessed on 21.12.2021.

² These locative components cannot be hosted on the website. Links to the AppStore

and GooglePlay are provided to download the Hidden Florence and Hidden Florence 3D apps.

³ The map interface was designed by David Heyman of AxisMaps (www.axismaps.com).

Figure 1
Florence 4D map interface with entry points to full digital assets as small 3D models overlaid onto the historical map layer.
© Florence 4D 2021



interpretation to assist with free exploration. One of these, “Spatializing Charity: The Innocenti in its context”, includes four separate datasets that work at different scales to contextualize the hospital and its artworks, to show how this major charitable institution of Renaissance Florence sat at the heart of multiple networks – of property ownership, artistic patronage, health provision, and poor relief. At the broadest scale we have plotted all known charitable institutions in the city, to show how the Innocenti is one of a vast network.⁴ Full details on the archival sources, and the secondary source from which these are derived, are included in the data ingested to the Omeka S database, ensuring that any subsequent reuse remains a transparent process. Such an approach to the geospatial visualization of existing research offers rich potential for the addition of geo-datasets through contributions from the wider scholarly community.⁵

Homing in on the Innocenti itself, the “property records” dataset presents data selectively ingested from the DECIMAGIS platform, containing records from the 1561 Decima tax census showing the Innocenti’s extensive property portfolio across the city.⁶ This socio-economic dataset confirms the varied nature of the charitable institution’s interests, revealing clusters of low-income housing managed on the urban periphery, and commercial, high-value rent

properties in the center. While of course this helps to illustrate the web of relations and endowments that sustained the hospital’s activities, it also invites users to explore and test how socio-economic census data can enrich our interpretation of the art and architectural evidence that is the principal focus of our project. In so doing it is a demonstration of the potential of linked open data (LOD) to radically scale up networks of structured data drawn from diverse repositories.⁷

A rather different approach is signaled in the “Marietta and her life” tour which invites users to experience spatial research in an embodied way, by linking to a walking trail in the *Hidden Florence* locative app, led by a *nocentina* (a foundling). Marietta, a composite character derived from historical records, is a foundling raised by the Innocenti who goes on to work as a silk weaver, offers an experiential and kinetic view of how Florentine institutions sustained and shaped the life of the urban poor.⁸ For our present purposes, however, the attention now shifts from this wider urban panorama at map scale, to the 3D modeling of lost architectural features and settings for works of art, in which more forensic attention is afforded to the material fabric of the building in a diachronic perspective.

The “Visualizing Arts” tour presents the artworks originally preserved in the hospital

⁴ Data drawn, with permission, from Henderson 2006.

⁵ There are some similarities here to the recent updates to DECIMA’s curated “project maps”, see <https://decima-map.net/maps/>.

⁶ For a discussion of this property portfolio, see Jamison 2016.

⁷ The potential for the convergence of various DH projects centred on pre-modern Florence is being promoted by the Florentia Illustrata consortium, coordinated from Villa I Tatti, Harvard University Centre for Italian Renaissance Studies, Florence; see https://dh.itatti.harvard.edu/#florentia_illustrata.

⁸ Read more at <https://hiddenflorence.org/stories/marietta/> with links to AppStore and GooglePlay; on locative apps as a research approach, see now the Open Access collection (Nevola/Rosenthal/Terpstra 2021).

Figure 2
Screengrab of the church of Santa Maria degli Innocenti interior, from the Unity 3D viewer within the www.florence4d.org website.
© Florence 4D 2021.



church of Santa Maria degli Innocenti; clicking any of these listed works launches the 3D viewer to reveal the item in its original context within the church interior, rendered for a series of different phases from the fifteenth to the eighteenth centuries, when the last renovation of the interior erased its Renaissance layout and caused the dismantling of the original altar structures. The research-based 3D model of the church virtually reinstates artworks now distributed elsewhere in the Museo degli Innocenti complex, as well as further afield, such as the terracotta angels that are now displayed in the Victoria and Albert Museum in London. As such, not only does the model provide a visualization of the church as a whole, it also proposes how individual altars might originally have been arranged.⁹ The 3D viewer for the model supports annotations in the form of hotspots that provide additional information via popups with links back to the underpinning metadata (fig. 2), discussed below. Furthermore, as the viewer is designed using the Unity engine, this has made it possible for us to repurpose these same models into location aware apps that allow users to explore the buildings at 1:1 scale in situ, in today's urban setting. We are currently finalizing updates to our *Hidden Florence 3D* app that will include the Innocenti church, again with information hotspots for location-based discovery.¹⁰

The discussion thus far has focused on the user experience through a discussion of the “Tours”

accessed through the ‘Map’ section on the website (also accessible from the homepage), broadly speaking geo-datasets presented on the map interface, 3D models accessed through the viewer, and links out to geolocated apps. Much of the project frontend has been designed to facilitate discovery through visualization in maps and 3D models, with design features that encourage understanding of the buildings as embedded within a complex urban ecosystem, and interpretative “Tours” that guide the user through meaningful connections in the data. However, as with all humanities research these visualizations, observations and interpretations rest upon multiple sources of evidence (archival, secondary scholarship, digital survey work etc.). These sources can be accessed from the fourth entry point from the homepage that points to the project database.¹¹

Metadata for each datapoint in the geo-data contained in the map interface, as well as for the artworks and features contained within the models, is included in an Omeka S database. Omeka S is an easy system to use, widely supported by University IT services, and allows us to import controlled vocabularies to structure the data. So, for instance, in the example of the predella from the Innocenti church high altarpiece (fig. 3), structured metadata indicates the object's typology through the Getty vocabulary URI, providing additional basic information such as might be found on a museum label.¹² Further, by adopting the CIDOC CRM ontology,

⁹ It is not possible to discuss our research-based modeling process in any further detail here; see Nevola *et al.* 2022.

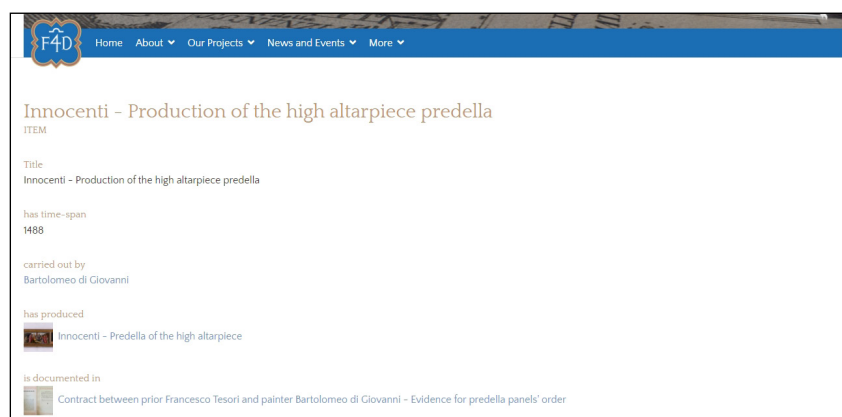
¹⁰ For an account of the San Pier Maggiore 3D AR app, see www.florence4d.org, “San

Pier Maggiore: A Neighbourhood Story”, as well as <https://hiddenflorence.org/hf-3d/> and its subpages. The open access app code is available at: <https://github.com/ZubrVirtualReality/Hidden-Florence>.

¹¹ www.florence4d.org/item/search.

¹² <http://vocab.getty.edu/page/aat/300003745>.

Figure 3
 Screengrab from the Omeka S data
 repository.
 © Florence 4D 2021.



it is possible to create semantic, machine readable links to events that led to the predella's production: for instance, an event-centric ontology places the production of the painting at the center of a set of relationships between actors, places and objects.¹³ Furthermore a digital representation may convey relationships that do not pertain to the physical object, but to its virtual surrogate – in this instance the digital reconstruction of the predella panel is arranged with each panel placed in the order as was originally commissioned, documented in a lost contract transcribed at the beginning of the twentieth century.¹⁴ The semantic data relationship explains such subtleties, making interpretation presented in the reconstruction intelligible, by providing such digital “footnotes” to the digital assets.

Such considerations are equally important for the 3D models themselves, where the mimetic quality of well-made visualizations is sometimes challenged by scholars for obscuring complexities or uncertainty contained in the evidential record. A multiplicity of features (from architectural finish – color of plaster, floor tiles, wood grains etc. – to ageing processes, light sources and so on) introduce varying degrees of conjecture to the modeling process. These elements of uncertainty can be addressed appropriately through supporting structured metadata that essentially provides an epistemological basis for the logically ordered elements of evidence that inform the visualization. As is so often repeated with digital humanities/ digital art

history work, such processes are iterative, and structured data means that new evidence can easily be brought into the system to adapt or update findings at a later date.

Conclusions

Projects such as Florence 4D adopt the affordances of “born digital” research, at once presenting innovative findings, and providing an open data repository that can be reused by other researchers. The value of standardized, semantically oriented, machine-readable metadata is that it is interoperable and through LOD protocols can be incorporated into other systems, just as we are able to draw on existing structured datasets for our own work. So, for instance, to remain within the context of digital spatial research on Florence, we have joined the *Florentia Illustrata* consortium (and the related *Metapolis* project), which is designed on a ResearchSpace web environment that harnesses LOD as a “a research and publication tool” to which multiple scholars will be able to contribute.¹⁵ Interoperable standards and cross institutional collaborations are key aspects in the future scalability of Digital Art History work.

As yet, the potentialities of such platforms to support 3D visualization and related metadata have not reached a sufficient maturity for shared standards and systems to have emerged. We have shown here that this should not constitute a barrier to presenting 3D models

¹³ <http://www.cidoc-crm.org/>; for a detailed discussion of an example see also Nevola et al. 2022.

¹⁴ Cadogan 2000, pp. 269–270, after documents transcribed by Gaetano Bruscoli and later lost. See Bruscoli 1902, pp. 18–19.

¹⁵ https://dh.itatti.harvard.edu/#florentia_illustrata and <https://dh.itatti.harvard.edu/#Metapolis>.



Figure 4

Screenshot from video (<https://doi.org/10.17617/3.IOLIEL>) describing the artistic and architectural transformations to the church of Santa Maria degli Innocenti that have taken place over the centuries.

as both fully contextualized within the map interface, and searchable from the structured database. Future work will focus on developing a closer integration of the semantic database with 3D models, contributing to the development of standards from the international image interoperability framework (IIIF) applied specifically to 3D.¹⁶ At the same time, as we have suggested here, rigorously research-based 3D models of

the sort described can be repurposed for use in public-facing contexts, as interpretative animation videos (fig. 4) in galleries and museums, or as location-aware apps delivered on ubiquitous consumer devices.¹⁷ In this way, by thinking holistically about the lifecycle of digital art history visualization work, researchers can shape new questions in the field, while also providing valuable resources to the wider public.

¹⁶ See <https://iiif.io/community/groups/3d/#about>.

¹⁷ See Nevola/Rosenthal/Terpstra 2022.

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Fabrizio Nevola, Donal Cooper, Chiara Capulli and Luca Brunke, "Immersive Renaissance Florence: Research-Based 3D Modelling in Digital Art and Architectural History", *Getty Research Journal*, vol. 15, (2022), pp. 203–227. Doi: <https://doi.org/10.1086/718884>.

Nevola/Rosenthal/Terpstra 2022

Fabrizio Nevola, David Rosenthal, and Nicholas Terpstra, *Hidden Cities: Urban Space, Locative Apps and Public History in Early Modern Europe*, London, 2022.

Abstract

Andrea Giordano, Paolo Borin

Visualizzare la complessità: Fondamenti BIM per il progetto Visualizing Cities

keywords – *BIM, Representation, Transformations, History, Digital Models*



The proposed work focuses on Visualizing Cities a research project that involves multiple academic institutions and emphasizes its collaborative and open-ended mission, as well as the interdisciplinary interaction and analytical methods offered by various technologies. The project uses Historical GIS cartography, content management system databases, interoperable 3D models (also known as Building Information Modeling or BIM), video and animations, 3D printed models, and mobile web-based applications. The aim is to demonstrate how new technology-supported methods can change and inform our ways of thinking and working. This project showcases how new technologies can transform research and teaching, applying theory and best practices in the field of Digital Humanities to interpret, represent, understand, and promote the knowledge of cities as spaces that evolve over time. The goal is to balance the digital description of heritage for research purposes with its operational management, aligning academic methods with the sustainable preservation of built heritage.

Dor: [10.48431/hsah.0208](https://doi.org/10.48431/hsah.0208)

Visualizzare la complessità: Fondamenti BIM per il progetto *Visualizing Cities*

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Assistiamo ormai a una abituale trasformazione dei modi in cui possiamo rappresentare il mutamento e la crescita delle città nel tempo attraverso le tecnologie digitali: infatti, mappe animate, in relazione a linee temporali, di modelli 3D geo-referenziati ci permettono di rappresentare la creazione di una città e dei suoi edifici come un processo continuo, potendo visualizzare anche come lo spazio urbano e architettonico rispecchi i cambiamenti sociali, economici, religiosi e politici. Per questo va evidenziato come le nuove tecnologie consentano narrazioni innovative della storia di una città e dei suoi edifici, ma anche della sua popolazione, laddove l'utilizzo di mezzi innovativi di comunicazione, visualizzazione e realtà aumentata – formati dinamici e coinvolgenti accessibili tramite internet, dispositivi portatili, mostre interattive e una varietà di strumenti di apprendimento – consente un racconto esaustivo della storia di luoghi, spazi e società.

La complessità percettiva per la rappresentazione delle trasformazioni storiche

Il lavoro qui proposto è una “estensione” del progetto *Visualizing Venice*¹, opera di tre istituti di ricerca: Duke University (Art, Art History & Visual Studies, Durham, NC)²; l'Università Iuav di Venezia (Architettura e Storia dell'Architettura)³, e l'Università degli Studi di Padova (LIMlab)⁴. Da *Visualizing Venice*⁵, l'attuale *Visualizing*

Cities eredita soprattutto l'aspetto collaborativo, come è possibile capire da mostre⁶, recensioni, pubblicazioni, conferenze e presentazioni su invito in Europa, Stati Uniti e Asia. Infatti i team di ricerca citati sono attualmente coinvolti in tale progetto con una gamma di competenze multidisciplinari: Storia dell'arte, Storia dell'architettura e della città, Rappresentazione (in particolare Rilievo dell'architettura, BIM – Building Information Modeling, GIS – Geographic Information System, restituzioni prospettiche e fotografiche), Ingegneria strutturale, Restauro e conservazione degli edifici. Come concetto globale, *Visualizing Cities* include attività teoriche e operative molteplici attraverso l'utilizzo di modelli animati e vedute della città, ricostruzioni e mappe interattive, quali modelli che non hanno solo una valenza accademica, ma si configurano come accessibili a un pubblico più ampio. Tale progetto risulta essere quindi il trait d'union tra la metodologia accademica e le possibilità offerte dalle nuove tecnologie. Il progetto ha anche delle ricadute per l'insegnamento e la formazione negli ambiti delle tecnologie digitali, attraverso corsi e workshop estivi⁷. Entrando nel merito dell'organizzazione di *Visualizing Cities*, va sottolineato il carattere multidisciplinare e open-ended del progetto, che coinvolge una grossa varietà di discipline e di metodi analitici generati dalle tecnologie utilizzate: cartografia storica rielaborata in termini GIS, sistemi di gestione dei contenuti documentali (banche dati), modelli

1 www.visualizingvenice.org.

2 Referenti scientifici: Caroline Bruzelius, Kristin Huffman, Victoria Szabo, Mark Olson.

3 Referenti scientifici: Donatella Calabi, Guido Zucconi, Alessandra Ferrighi.

4 Referenti scientifici: Andrea Giordano, Elena Svalduz, Cosimo Monteleone.

5 Huffman/Giordano/Bruzelius 2018.

6 Si vedano ad esempio al Palazzo

Ducale la mostra *Acqua e cibo a Venezia.*

Storie della Laguna e della Città (URL: <https://palazzoducale.visitmuve.it/it/mostre/archivio-mostre/mostra-acqua-e-cibo/2015/04/7052/storie-della-laguna-e-della-citta/>), e alla Bi-City Biennale of Urbanism/Architecture di Shenzhen l'allestimento *Visualizing Venice*, new technologies for urban history Italian pavilion (URL: <http://www.visualizingvenice.org/>

[visu/?p=642](http://www.visualizingvenice.org/visu/?p=642)).

7 Come, ad esempio, il workshop del 2019, tenuto alla Viu – Venice International University, intitolato *Advanced Topics in Digital Art History: 3D and (Geo)Spatial Networks* (URL: <https://www.univiu.org/study/summer-schools/visualizing-venice>).

3D (anche interoperabili – BIM – e interattivi), video e animazioni, modelli prototipati e applicazioni per dispositivi mobili e web. Lo scopo è quello di dimostrare come le nuove metodologie generate dalla tecnologia possano cambiare e informare il nostro modo di pensare e lavorare.

Il progetto testimonia pertanto come le nuove tecnologie abbiano la capacità di “rivoluzionare” la ricerca e l’insegnamento implementando teoria e pratica per così dire collaborative nell’ambito delle Digital Humanities, per interpretare, rappresentare, insegnare e promuovere la conoscenza di una città come spazio nel tempo. In questo senso, quindi, *Visualizing Cities* accoglie uno degli aspetti più innovativi delle tecnologie digitali: la consapevolezza che il pensiero speculativo degli studiosi non si esprime al massimo delle sue possibilità se, per adeguarsi al mondo bidimensionale che caratterizza normalmente la documentazione storica, si libera del corpo e, conseguentemente, delle percezioni 3D⁸. Il senso di questo lavoro consiste nel superamento di un’idea delle funzioni cognitive cristallizzate esclusivamente sul linguaggio e sulle immagini statiche, che rimangono tuttavia enti fondativi del pensiero critico e del metodo proposto. Nuove modalità di rappresentazione – con animazioni e modelli 3D – contribuiscono a una figurazione mentale dello spazio tridimensionale che non è più statica, ma è sostenuta dall’azione, pur trattandosi di dinamismo virtuale. Questa impostazione innesca una simulazione interna che porta lo studioso a giudizi, scelte e riflessioni più consapevoli. Ciò accade perché la consapevolezza che un individuo possiede dello spazio si acquisisce naturalmente nel tempo, passando attraverso gli oggetti con i quali interagiamo nella vita reale; quando un osservatore è costretto a un confronto con il mondo 2D dell’astrazione documentaria, molte sicurezze si indeboliscono⁹.

In questo senso, le ICT – Information and Communications Technologies – sono uno ausilio straordinario a disposizione degli studiosi: attraverso di esse è possibile ricreare uno spazio virtuale, capace di assottigliare la distanza tra astratto e concreto. *Visualizing Cities* mira alla ricostruzione dei cambiamenti dell’architettura e della città nel tempo, laddove

l’analisi storica dei luoghi viene espressa principalmente attraverso modelli virtuali 3D, possibilmente rappresentati in ambientazioni fisicamente immersive. Questo approccio stimola i sensi umani per favorire maggiormente l’intuizione empirica dell’osservatore, amplificando la funzione dell’illustrazione scientifica, che può essere considerata come una manifestazione sia della sintesi delle informazioni obiettive e sia dei sentieri battuti dal rigore logico. Le trasformazioni storiche e urbane nel tempo, espresse dinamicamente, agiscono quindi da facilitatore di concetti scientifici, anche complessi, immergendo un generico visitatore – ma non solo, anche lo studioso, lo studente – in attività virtuali simulate che sfruttano il senso del movimento, il solo in grado di anticipare ciò che sta per accadere nella realtà. È ormai appurato che le facoltà cognitive si siano affinate proprio grazie al movimento, secondo processi evolutivi collegati alla percezione dinamica del mondo, che spingono l’uomo ad adattare il proprio comportamento a un ambiente in moto perpetuo. Questa attitudine del pensiero, quella cioè che misura e prefigura il movimento, non si limita a fare da base iniziale ai pensieri, ma li accompagna nel loro sviluppo attraverso la rappresentazione degli oggetti immersi nello spazio immaginato¹⁰.

Per concludere, *Visualizing Cities* si configura come un progetto di ricerca potenziato dai mezzi tecnologici e caratterizzato da prodotti “immateriali”: esso si arricchisce inoltre di sfumature ecumeniche, poiché i contenuti digitali, resi pubblici on line, possono essere considerati come nuovi punti di partenza per ulteriori approfondimenti da parte di tutti gli interessati. Rispetto al classico libro di storia dell’architettura e della città, chiuso e concluso, il sistema di conoscenza innescato da un sapere multimediale si presenta all’opposto, aperto e dinamico; all’interno di questo ambiente scientifico tutti – appassionati, studenti, critici o semplici curiosi – possono contribuire in momenti successivi con i loro apporti e le proprie intuizioni. Quando nel Rinascimento Leonardo mette a confronto il mondo della rappresentazione con quello della scrittura, sostenendo la supremazia del primo sul secondo, egli arriva a considerare la capacità

8 Monteleone 2018, pp. 67–75.

9 Monteleone 2018, pp. 67–75.

10 Berthoz 1998 e Negrotti 2012.

comunicativa della pittura alla stessa stregua di una poesia muta, perché essa è in grado di toccare i sensi e far conoscere i fatti in un solo sguardo e senza l'ausilio delle parole¹¹. Viceversa, egli definisce la poesia una pittura cieca, cioè un'immagine che si forma nella mente solo dopo aver ascoltato il lento susseguirsi delle parole. [Andrea Giordano]

Per una produzione di modelli digitali informativi multi-obiettivo

Al fine di essere pienamente operativo ed efficace, il progetto *Visualizing Cities* deve dotarsi di flussi di lavoro capaci non solo di supportare la visione del progetto, ma di fornire una corretta trasformazione delle informazioni della ricerca svolta, in ogni caso studio, in un nuovo documento. Tale documento, che non potrà che avere la forma digitale, è previsto essere un modello BIM¹²: si tratta dell'utilizzo di una rappresentazione digitale condivisa che crei una base decisionale affidabile in modo da facilitare i processi di progettazione, costruzione/restauro/recupero ed esercizio di un bene costruito. Affinata nella ricerca a partire dagli anni '70¹³ e utilizzata nella pratica professionale a sostituzione della modellazione generica CAD per l'industria delle costruzioni, tale metodologia è stata scelta perché è la più opportuna per documentare le trasformazioni urbane e architettoniche nella storia.

A seguito dell'esperienza pluriennale del gruppo di lavoro dell'Università di Padova¹⁴, si dimostra come le esigenze informative dei modelli digitali per lo studio delle trasformazioni storiche sono pari a quelle per la gestione di edifici esistenti e di nuova progettazione¹⁵. Se i partecipanti di un progetto architettonico sono diverse figure professionali, progettisti, consulenti esterni – ad esempio per il calcolo dei consumi energetici e la progettazione antincendio –, le società di costruzione e i clienti, gli attori diventano, secondo il tipico flusso di lavoro confezionato per *Visualizing Cities*, storici dell'arte e

dell'architettura, esperti di realtà aumentata e virtuale, curatori di mostre, eccetera¹⁶.

Risulta innanzitutto fondamentale costituire un modello 3D dell'esistente attraverso le informazioni provenienti da un rilievo. In presenza di edifici ancora esistenti, gli strumenti per la produzione di un modello BIM da rilievi digitali sono particolarmente efficaci, garantendo al modellatore esperto l'accuratezza critica necessaria nell'inserimento delle informazioni geometriche e costruttive (muri, archi, elementi decorativi). Qualora l'edificio non fosse più esistente, si tratta di mettere a sistema informazioni grafiche e documentali – piante, sezioni, relazioni di rilievo – che permettano di costruire un'unica rappresentazione – il modello BIM – come sola fonte informativa. Tale processo obbliga tutti gli attori a una serie di scelte che rendono alcune informazioni (ad esempio, la posizione di una finestra in un edificio religioso, l'estensione di un sistema voltato in un edificio pubblico) primarie rispetto ad altre. Per agevolare in chiave digitale il continuo pensiero critico, è necessario in primo luogo allestire un ambiente collaborativo che permetta ai ricercatori di inserire e validare le proprie scelte, comunemente chiamato *Common Data Environment* (CDE). Ciò non permette solo la virtualizzazione online dei modelli da più postazioni e la segnalazione di problemi ed errori. L'ambiente in questo caso deve garantire il collegamento tra elementi del modello e documenti che garantiscano e avvalorino le scelte di modellazione fatte¹⁷.

Per questo fine, si segnala come il modello debba essere adeguatamente redatto, al pari di un testo con una corretta grammatica, per poter essere pienamente compreso dal lettore. In particolare, il modello sarà ben svolto quando assolverà ad alcuni utilizzi specifici del caso studio: può essere ad esempio a servizio di un'analisi visiva dell'ambiente esterno che un monaco osservava durante la preghiera, oppure essere in grado di fornire la quantità e il tipo

11 Da Vinci 1651.

12 ISO 19650-1:2018, pp. 4–7.

13 Eastman 1975, p. 46.

14 Giordano et al. 2018.

15 Per esemplificare tale concetto si useranno termini e acronimi tipici della

pratica BIM, comunque ritrovabili all'interno della normativa internazionale ISO 19650-1.

16 Un ulteriore ruolo che rimane invariato è la figura di un esperto BIM, trasversale alle figure di BIM Manager e BIM Coordinator, che sappia gestire le informazioni in un flusso

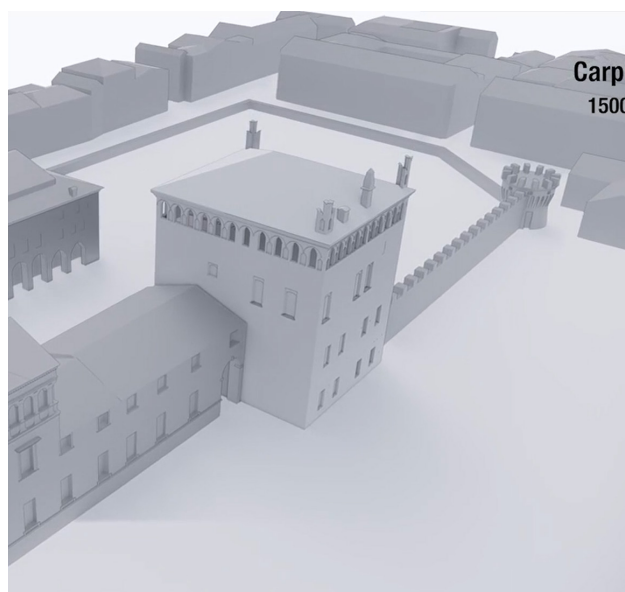
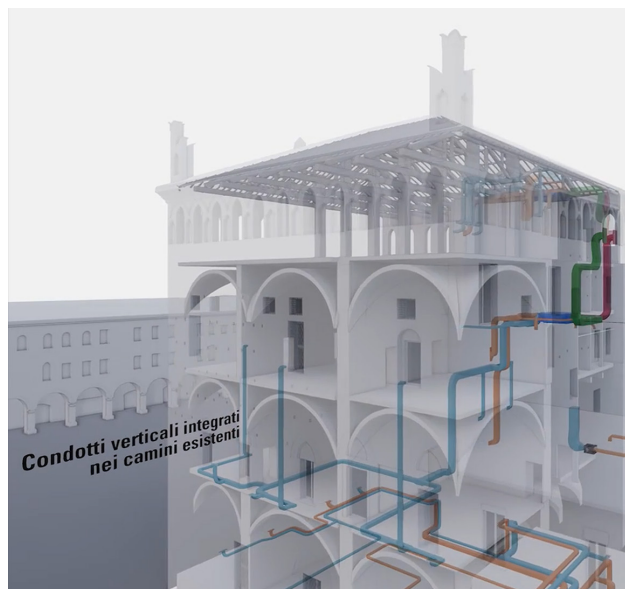
coordinato e coerente.

17 Questo processo non è affatto distante dal collegare la scheda prodotto di un serramento all'interno di un modello di nuova costruzione.



Figura 1
Ricostruzione da fonti iconografiche differenti di un modello BIM di un'abitazione del Ghetto Nuovo di Venezia.
Autore P. Borin.

Figura 2a-2b
Modellazione della città di Carpi e illustrazione del progetto di recupero dell'edificio del Torrione.
Elaborazione LIM.lab-UNIPD.



di oggetti lapidei presenti per confrontarli con le minute di acquisto, o eventualmente verificare particolari percezioni prospettiche legate a procedure liturgiche di un ambiente ecclesiastico. Può infine collegarsi a modelli di dati esterni, seguendo, o armonizzando, ontologie tipiche di altri domini della conoscenza¹⁸. L'aspetto senza dubbio più semplice e molto spesso utilizzato è quello di poter parcellizzare gli elementi costruttivi per associarne ciascuno a un'epoca storica, raggiungendo così l'obiettivo di restituire la realtà costruita con un unico modello nella sua evoluzione storica¹⁹.

Ne consegue un importante risultato di processo all'interno della collaborazione tra storici dell'arte ed esperti di visualizzazione (fig. 1). Pur assolvendo naturalmente alla produzione di oggetti multimediali, il modello BIM non può nascere a conclusione di uno studio, ma risulta, nelle pratiche più avanzate, di appoggio, confronto e continua verifica dello studio. A maggior ragione risulta rilevante definire gli obiettivi della modellazione all'inizio dello studio, definendo eventuali utilizzi del modello in un documento di sintesi, che viene specificato dalla normativa *BIM Execution Plan* (BEP) (fig. 2).

¹⁸ Borin/Bernardello/Grigoletto 2020.

¹⁹ Tale pratica, nelle sue operazioni software, non differisce in nulla nella

programmazione di un cantiere per l'esecuzione di un edificio.

Il continuo rimando a operazioni tipiche della realtà professionale non ha lo scopo di banalizzare le operazioni, ma, al contrario, di fornire due straordinarie occasioni.

In primo luogo, se gli edifici sono esistenti, il proprietario degli asset immobiliari, spesso pubblico, a seguito di uno studio storico, può utilizzare i modelli per scopi di salvaguardia e conservazione operativa del bene. Viceversa, qualora tale modello BIM fosse già esistente, i ricercatori possono usufruirne per iniziare le proprie considerazioni, arricchendo il modello di informazioni, e di significato. Questo duplice processo sembra particolarmente importante in direzione di una completa digitalizzazione dell'ambiente costruito, tale da permettere la sostenibilità economica degli approfondimenti storici sul patrimonio esistente.

In seconda istanza, è invariata la disponibilità tecnologica e operativa degli utenti capaci di operare sui modelli BIM: ciò permette ad esempio di rendere possibili dei progetti che utilizzino laboratori didattici a supporto di studi relativi alle trasformazioni urbane. Tale scelta dipende innanzitutto da mere questioni operative, legate al fatto che un sistema complesso come quello descritto nei paragrafi precedenti non sia di facile gestione e concettualizzazione. Per questo motivo è necessario creare figure professionali che sappiano coordinare pienamente le informazioni circa gli edifici di pregio e le loro trasformazioni storiche. [Paolo Borin]

Conclusioni

Il progetto *Visualizing Cities* ha come obiettivo il superamento dei limiti cristallizzati di spazio

e di tempo della rappresentazione rinascimentale; il supporto fornito dall'ICT permette la creazione di modelli 3D arricchiti di dati che possono essere adoperati per l'analisi e le simulazioni relative alle trasformazioni dello spazio urbano e dell'architettura. E non solo. L'uso avanzato di modelli intelligenti – BIM – ha esteso il campo di applicazione ben oltre le tre dimensioni, inglobando in sé concetti come il tempo, le misurazioni digitali compiute sul campo, la documentazione storica raccolta in archivio, i materiali costruttivi, etc. Un modo semplice per comprendere l'ampia gamma di possibilità che si apre nel mondo virtuale consiste nel pensare tale modello 3D come una piattaforma in cui è possibile, al di là del dato formale, caricare numerose altre informazioni, che a loro volta possono essere organizzate e stratificate nel tempo. Oggi le discipline del Disegno e della Rappresentazione accompagnano la Storia dell'architettura e della città in tutte le sue fasi, dalla registrazione dello stato di fatto di un ambiente urbano attraverso il suo rilievo digitale – laser scanner e fotogrammetria – all'interpretazione della documentazione storica (catasti, mappe, vedute urbane, incisioni, dipinti, piante, prospetti e sezioni degli edifici); dalla ricostruzione dei documenti nello spazio virtuale per mezzo di modelli 3D alla divulgazione delle interpretazioni analitiche a diversi livelli di complessità, coinvolgendo il turista, lo studente e lo studioso. La rigida e antica dicotomia che vede contrapposta la pittura (rappresentazione) alla poesia (scrittura/storia) è definitivamente superata, perché la modellazione 3D dell'architettura e della città permette di generare vere e proprie immagini parlanti in un mondo virtuale pluridimensionale e in divenire.

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Abstract

Ruggero Longo

Digitizing Cultural Heritage. Methodology, Potential,
and Limits of the Palermo Royal Palace Project

keywords – Norman Palermo, Royal Palace,
Cappella Palatina, 3D survey, Digital surrogate



The Royal Palace in Palermo, with its famous Cappella Palatina and the so-called Norman Stanza, is an outstanding, intricate architectural palimpsest. The three-dimensional model of the Palace represents an effective, useful tool, thanks to which a deeper knowledge of the monument arises. Besides a short description of the Royal Palace Project, which includes the trans-disciplinary approach applied to the monument in its complicated architectural history and archaeological stratigraphy, part of this contribution is dedicated to the epistemic rationale of the digital humanities, 3D models and digital tools, exploring potentials, questions and limits deriving from vast amounts of data, with the consequent need for an appropriate, dedicated and permanent management system. Compared to the traditional scientific outcomes represented by definitive publications and books, a never-definitive digital model would represent a dynamic tool, potentially open to an unlimited incrementation of data, and fostering a hermeneutic update and the heuristic upgrade of knowledge of a given cultural heritage monument. This increase of knowledge balances the degree of uncertainty of our working hypotheses and reconstructions, fundamental tools to retrace the diachronic history of a given monument and to recreate a reliable configuration of synchronic spaces and functions.

Dor: 10.48431/hsah.0209

Digitizing Cultural Heritage. Methodology, Potential, and Limits of the Palermo Royal Palace Project

Ruggero Longo

Digital Humanities, as the combined terms indicate, explicitly merges scientific and humanistic disciplines, logical and intuitive approaches, and mathematics and aesthetics, and takes for granted that science is not just an ensemble of specific disciplines, such as physics or chemistry, but a method.¹ In this sense, a digital humanist today is not simply an archaeologist, an architect or an architectural historian, or a computer scientist. My point of view in this essay is that of an art historian, armed with archaeological and archaeometric approaches, accustomed to interdisciplinarity, but who deals primarily with visual languages. Thus, I will focus my methodological analyses and criticisms on what we can rightly describe as visual languages, be they 2D, 3D, 4D, etc.

As an introduction to my argument, I would like to share a statement by Erwin Panofsky, which sheds some light on the limits of the aesthetic approach in the humanities, and in particular in art history:

[An Art Historian] constitutes his “material” by means of an intuitive aesthetic re-creation [...] How, then, is it possible to build up art history as a respectable scholarly discipline, if its very objects come into being an irrational and subjective process?²

Referring explicitly to Immanuel Kant's *Critique of Judgment*,³ Panofsky acknowledges that the aesthetic process, constituted by a relationship between the subject and the object, is a subjective one. The solution that he proposes consists in combining an aesthetic approach with an archaeological one, ensuring that the two processes interpenetrate one another:

Intuitive aesthetic recreation and archaeological research are interconnected so as to form, again, what we have called an “organic situation.”⁴

In other words, to mitigate the subjectivity of hermeneutic processes dealing with visual languages, Panofsky proposes to adopt an archaeological approach, thus introducing interdisciplinary studies and anticipating the need to start from objective bases, recently postulated for the field of 2D and 3D reconstructions by theorists such as Kevin Garstki.⁵ Panofsky's words also indicate the necessity of adopting transparent methodological paths that preclude the axiomatic assumption of objectivity of the visual data, a necessity recently theorized by many scholars, including Garstki himself as well as Susan Schreibman and Costas Papadopoulos.⁶

The comparison, in this regard, between photography and digital three-dimensional models has been often highlighted in a manner that goes beyond the similarities with Walter Benjamin's reproducibility and the ‘aura’ of the work of art⁷ – which Adam Rabinowitz redefined as “the Age of Digital Surrogacy”.⁸ Photography has long been employed as an indispensable, objective methodological tool in archaeological excavations, yet as Benjamin and Rabinowitz remind us, it acquires its authenticity, its aura, its purely subjective dimension, as a medium capable not (only) of translating and conveying reality, but rather of interpreting it. Similarly, the act of digital re-constructions is not an objective process, but a creative one, a form of rendering that performatively cites the original starting point.⁹ As with photography, is digital recreation thus a scientific method of

1 Russell 1914.

2 Panofsky 1938, pp. 103–104.

3 Kant 1790.

4 Panofsky 1938, p. 105.

5 Garstki 2017.

6 Schreibman/Papadopoulos 2019.

7 Benjamin 1968.

8 Rabinowitz 2015.

9 Garstki 2017.

Figure 1
View of the three-dimensional model of the
Royal Palace in Palermo.
Graphic: TecnoArt; © A.R.S. 2015.



replicating and translating reality, or a creative way of interpreting it? And subsequently: where is the boundary between art and science, subjectivity and objectivity, or to use Bertrand Russell's words, mysticism and logic?¹⁰

Be that as it may, like photographs, the three-dimensional renderings do not represent the objects themselves in their totality, but a single phase of their lives: a snapshot. In this paper, I will employ as my example a snapshot created in 2014–2015 of the Royal Palace in Palermo (fig. 1). The circumstance for this performance was the project “Knowledge, Cultural Promotion and Public Enjoyment of the Royal Palace in Palermo, 2014–2015.”¹¹

The Royal Palace is a significant architectural palimpsest, encompassing remains from across the entire history of Palermo, from the Punic-Hellenistic and Roman eras to the Norman period, and from early modernity to today. The importance of this site was made clear between 1984 and 1986, when some sections of the Punic and Hellenistic city walls were discovered below the Palace, together with one of the most ancient city gates of Pànormos, as Palermo was then known. More than 2500 years of history have produced a site of incredible archaeological complexity, the constructional stratigraphy of which is extremely difficult to investigate.¹² According to late 11th-century Latin sources, the Normans founded a fortress soon after they conquered Palermo in 1072.

The reconfiguration of the building undertaken in the 16th and 17th centuries by the Spanish court and the addition of early modern structures reshaped the medieval castle into a modern palace (fig. 2). A number of medieval Latin and Arab texts and documents permit us to arrive at a hypothetical reconstruction of the Norman Palace as it appeared in the late 12th century (fig. 3, fig. 4).¹³ The place where the Normans built the palace did not consist of a natural hill. The whole palace lies at an altitude eight meters higher than the Punic levels (fig. 5), a gap filled with stratifications belonging to pre-Norman phases of construction that were in need of better understanding.¹⁴ Importantly, the physical context that surrounds the famous Cappella Palatina – a wonderfully preserved cornerstone of medieval Mediterranean art – had never been properly investigated.¹⁵ The idea for a comprehensive project focused on the study of the Royal Palace was prompted by Maria Andaloro in 2009.¹⁶ The pioneering holistic approach¹⁷ aims to re-contextualize works of art within their original – and often lost – medieval spaces, a project that requires combining different disciplines in order to produce and convey knowledge. A multidisciplinary team from Tuscia University was in charge of the project, which I had the responsibility to coordinate. This challenging endeavor was performed in collaboration with Tecnoart, a company that specialized in innovative information technologies for the presentation and study of cultural heritage.

¹⁰ Russell 1914.

¹¹ PO-FESR 2007–13, CIG: 4397878889. Concept by Maria Andaloro; Sponsored by European Community – Regione Sicilia Assemblée Regionale Siciliana. Scientific Director: William Tronzo; Executive

Coordinator: Ruggero Longo; Executive Director: Pasquale Riggio; Executive teams: Università della Tuscia, Tecno Art s.r.l.

¹² P. Longo 2011.

¹³ R. Longo 2011; R. Longo 2016.

¹⁴ Giarrusso/R. Longo 2018.

¹⁵ Longo/Romagnoli 2018; Brunazzi/De Santis 2020.

¹⁶ Andaloro 2011a.

¹⁷ See, for instance, Andaloro 2006.

Figure 2

Carlo Castiglia, *Teatro Geografico Antiquo y Moderno del Reyno de Sicilia*, 1686: Palermo, view of the Royal Palace of Palermo (Madrid, Ministerio de Asuntos Exteriores y de Cooperación, Archivo General y Biblioteca, Ms. 3). Consolo/De Seta 1990, p. 264, fig. 51.

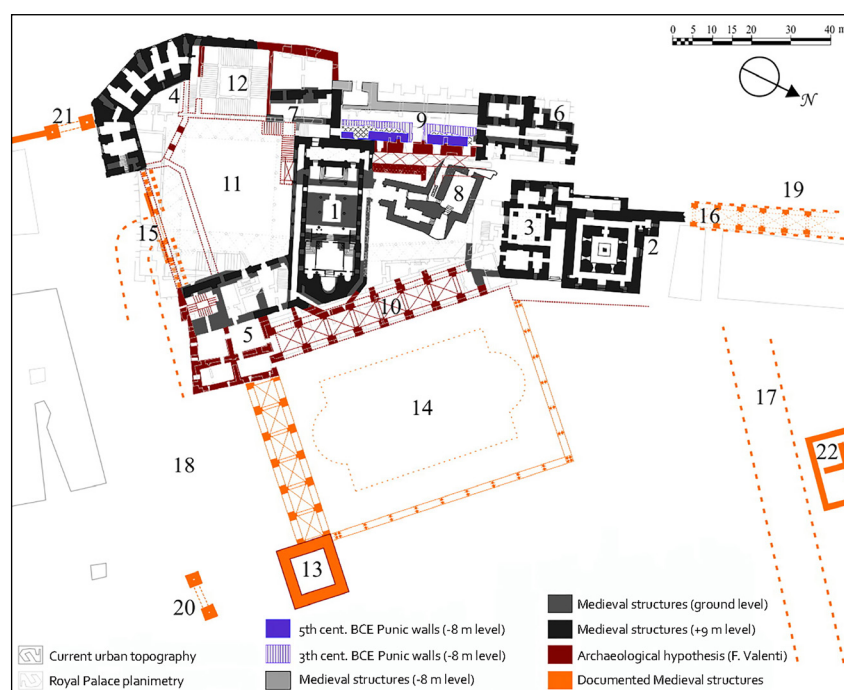


Figure 3

Map of the Royal Palace in Palermo, with surviving Medieval structures (grey) and structures hypothesized by F. Valenti or documented by historical sources (orange and red):

1. Cappella Palatina; 2. "Pisana" tower;
3. "Joharia"; 4. South-West Bulwark;
5. "Greek" tower; 6. Royal apartments;
7. Cappella Palatina treasury; 8. Dungeons (beneath "Cortile della Fontana");
9. Punic walls (beneath Sala Montalto);
10. Maqueda wing and modern façade;
11. Maqueda courtyard; 12. Monumental stairs; 13. "Red" tower; 14. "Aula regia" room; 15. Medieval entrance gate; 16. "Via cooperta" passageway; 17. "Simat" or "vicus Marmoreus" main street; 18. "Vicub ab aula regia" secondary street; 19. City walls;
20. "Galka" city gate; 21. "Bāb al-abnā" o "Porta Palatii" city gate; 22. Santa Maria della Pinta church.

Graphic: Ruggero Longo.



I wish here to highlight two aspects of the project. The first is related to the concept of epistemological objectivity and transparency. In 1933 Alfred Korzybski stated, "A map is not the territory it represents, but, if correct, it has a similar structure to the territory, which accounts for its usefulness."¹⁸ Well aware that a model is only a way to simplify reality, and that objectivity is only a chimera – something to aim for, but impossible to achieve or encompass,¹⁹ as relativity, quantic physics, and Heisenberg's uncertainty principle have

demonstrated²⁰ – and cognizant of Panofsky's assumption, our archaeological approach sought to integrate historical data, materials, and knowledge deriving from scientific analyses – physical, chemical, geological, mineralogical, hyperspectral – with visual-aesthetical data. The digital surrogates produced through this process, although missing aura, physical substance, scale, life, context, and experience,²¹ are capable of incorporating material data and evidence into the visual model. More than a simple virtual replica or a digital twin, the

¹⁸ Korzybski 1933, p. 58.

¹⁹ Russell 1914.

²⁰ Rovelli 2020.

²¹ Jeffrey 2015.

Figure 4
Drawing with the hypothetical reconstruction of the Norman Palace with indications of the medieval structures and buildings (Ruggero Longo). Based on a drawing by Paolo Loiacono under the direction of Francesco Valenti, published in Valenti 1925, pp. 512–528, fig. 13.

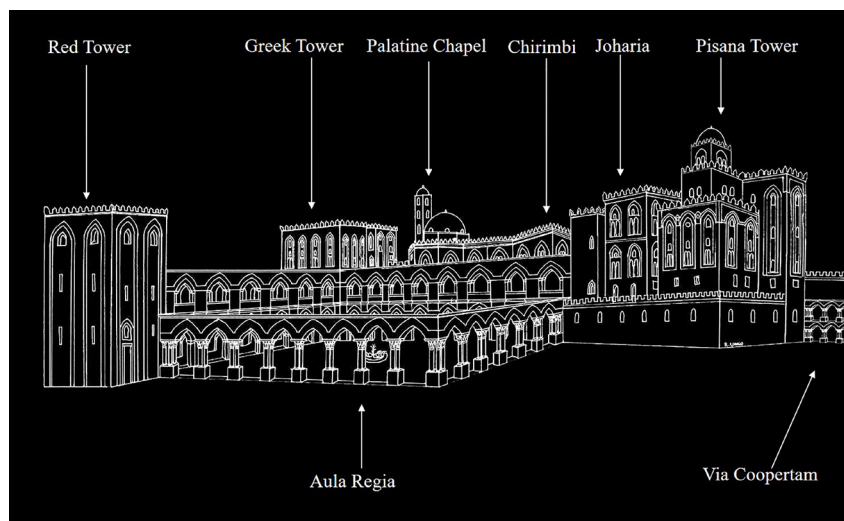
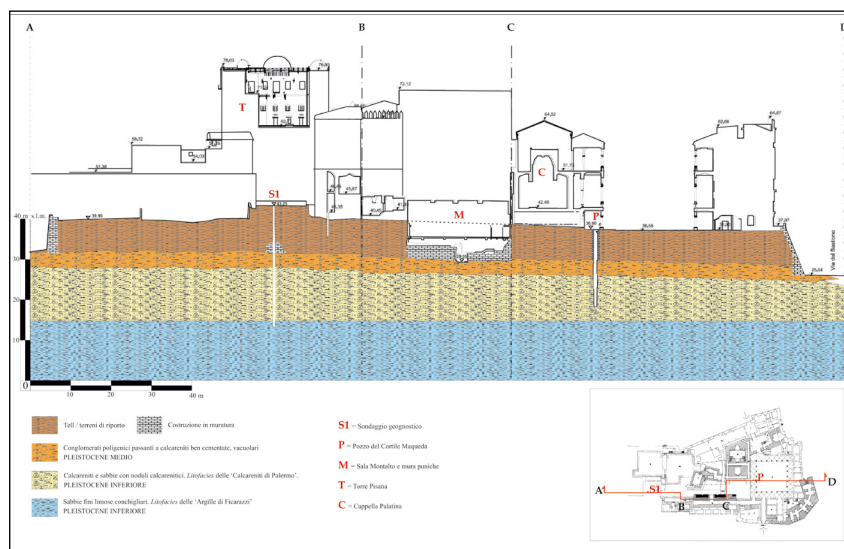


Figure 5
North-South cross-section of the Royal Palace in Palermo, including the geological section underground. Graphic: Ruggero Longo (Giarrusso/R. Longo 2018, fig. 17).



surrogate thus becomes something else in comparison to the original starting point: it is identifiable as a new creation. The power of this sort of digital copy lies precisely in its ability to supersede the original object to convey more pieces of information and to do so as they are perceived, recorded, and interpreted. It thus opens avenues to scientific approaches, while also making processes, and uncertainties, trackable and transparent.

The second aspect to be considered is that by analyzing the workflows of different processes during the creation of the digital reconstructions, we could individuate two opposite vectors: one is progressive, as it starts from surviving archaeological evidence and other more readily available data, and reconstructs the lost, disappeared past; the other is regressive, as it starts from the current configuration of the space and

architecture – i.e., the product of alterations, transformations, and stratifications – and excavates backward through it until a previous configuration comes to light. In both cases, it is essential to start from objective evidence. However, in the first case, our ‘time machine’, although returning back into the past (in a time before a given destruction occurred), will mainly move forward, in a constructive direction. In the second case, instead, the process starts from the present, returning back to the past through a destructuring process (in a time before a given new phase of construction and stratification happened). The Royal Palace case study began with a regressive approach: before modeling reconstructions, we performed a laser scan three-dimensional survey of the current configuration of the monumental complex. The utility of such a survey is obvious, for it

Figure 6
Creation of the three-dimensional model of the Royal Palace in Palermo. Above: workflow with buildings layers; below: point cloud and horizontal cross-section.
Graphic: TecnoArt.

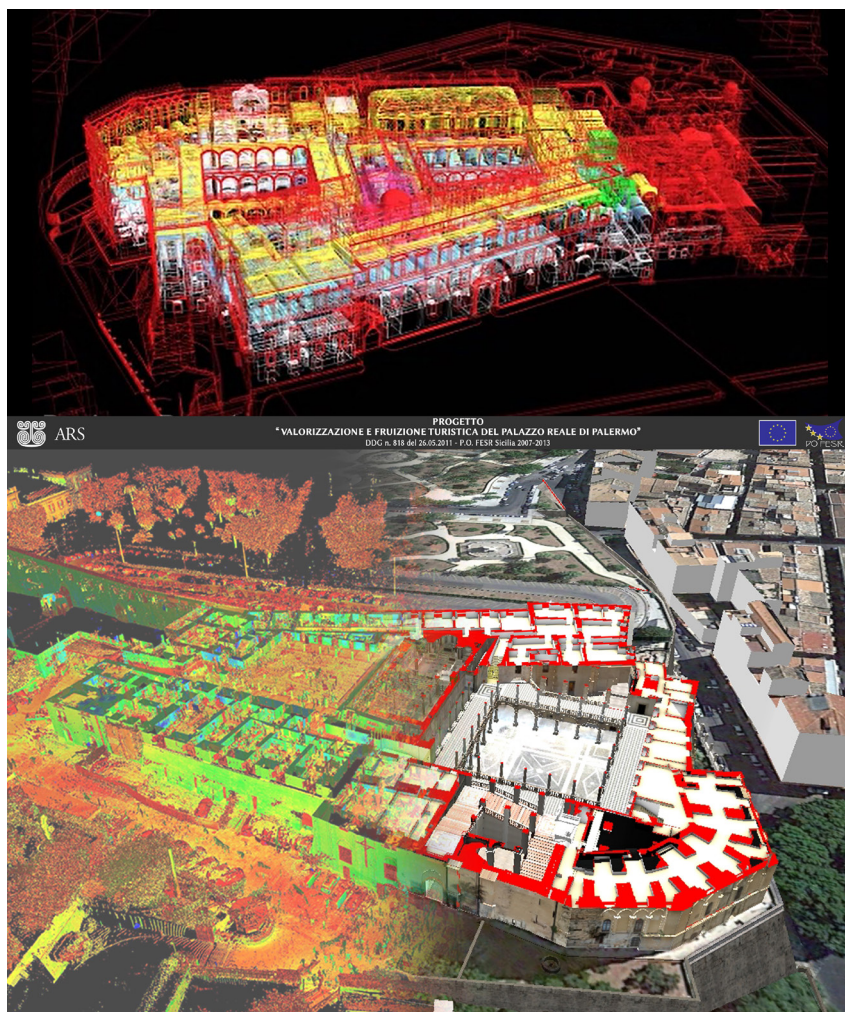


Figure 7
Cross-sections of the Royal Palace in Palermo, with the Cappella Palatina; above: three-dimensional model; below: AutoCAD output.
Graphic: TecnoArt; © A.R.S. 2015.

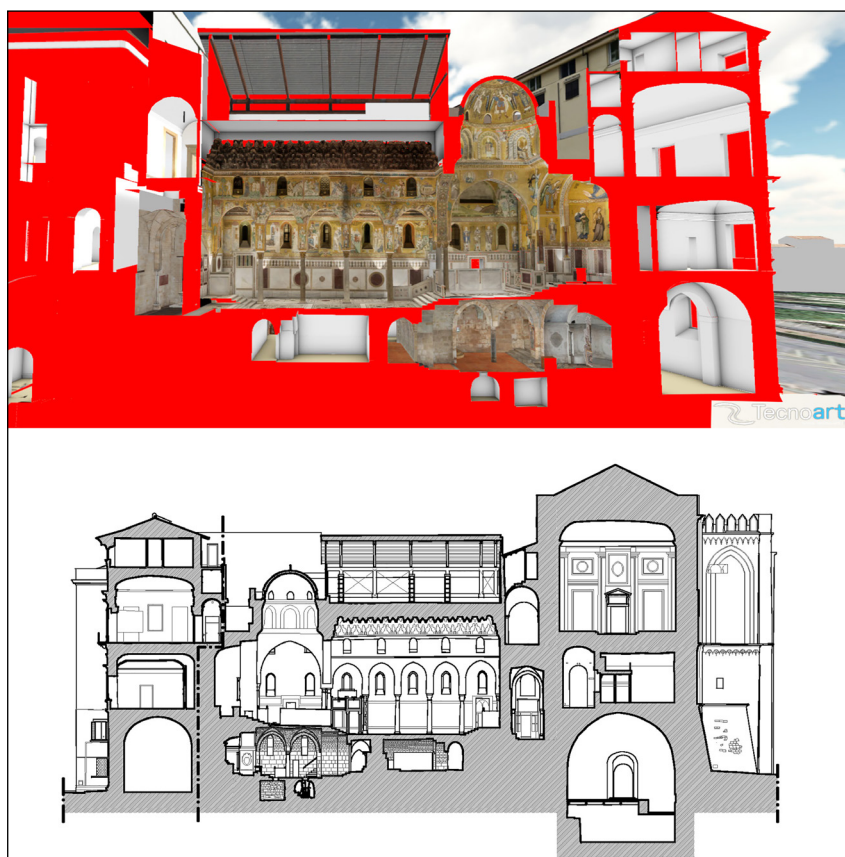
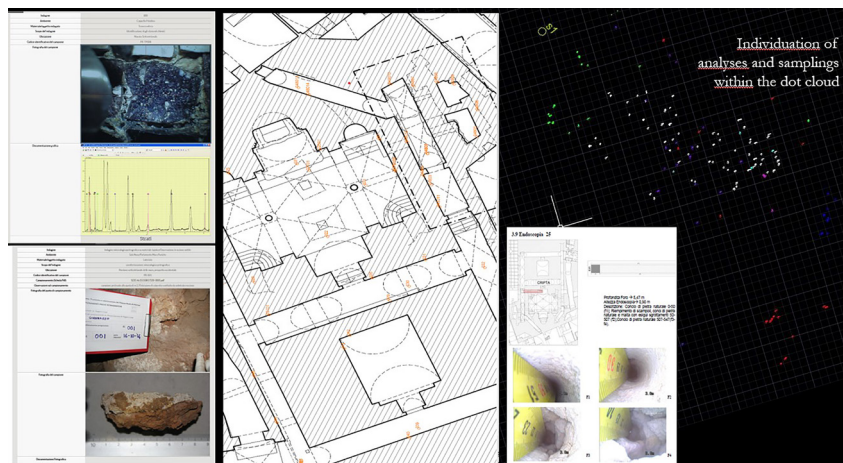


Figure 8
Georeferenced mapping of scientific investigations and analyses performed within the Royal Palace in Palermo.
Graphic: TecnoArt.



permits us to extract any plan or cross-section (fig. 6, fig. 7).

But the 3D model alone does not represent the real strength of the project. As part of our collective research, we carried out numerous types of scientific analyses, including identification of mortars and building stones, chemical analyses of mosaic glass tesserae, georadar and thermographic imaging, hyperspectral photography, and mapping of the mosaic surfaces. Focused databases preserve all the outcomes, files, documents, and information derived from these analyses, as well as from bibliographic and archival research. The innovative aspect arises from the manner in which the 3D model serves as a virtual platform or container, making it possible to present the data in their precise spatial and topographic context (fig. 8).

Such innovative methodology offers the chance to study the Royal Palace in a new way. Applications of this advanced tool can help to clarify the intricate relationships among the construction phases of the building, the still uncertain relative chronologies, and the original configuration of the medieval space. The most important findings of this project were presented in June 2018 at an international conference which I organized together with Maria Andoloro, William Tronzo, and Jeremy Johns.²² One example will suffice: the resolution of a crucial issue related to the medieval configuration and function of

the Cappella Palatina. Many scholars, starting from Ernst Kitzinger,²³ based their interpretations of the arrangements of mosaics, internal distribution of spaces, and multiple functions of the Cappella Palatina upon the existence of a *royal loggia*, located on the north wall of the sanctuary, from which King Roger II would have followed ceremonies from a privileged point of view (fig. 9).²⁴ The loggia that we see today is the result of mid-19th-century alterations, but in 1992 Kitzinger published a precious drawing executed in 1790 by Leon Dufourny, which attests to the existence of the loggia before the 19th century.²⁵ Other scholars had questioned the existence of the balcony in the Middle Ages, on the basis of interpretations of some late 16th and 17th-century documents.²⁶ Thanks to a deep analysis of the historical sources and the investigations performed on the architectural context around the chapel, it has been possible to verify that the first transformation of the openings occurred in 1585 when a new portico was built, the vaults of which obliterated the original windows on the north side of the chapel, thus modifying the loggia (fig. 10). The use of infrared imaging on this element has enabled the detection of the medieval openings (fig. 11), leaving room for interpretations (fig. 12) that may bring new life to Kitzinger's compelling hypotheses.

Before concluding, I wish to present some drawbacks to the approach used in this project.

22 Andoloro/Longo forthcoming.

23 Kitzinger 1949. 24 Ćurčić 1987.

25 Kitzinger 1992, pl. E.

26 Brenk 2010; Aurigemma 2010; Brenk 2014.

Figure 9
Drawing of the longitudinal cross-section of the Cappella Palatina in Palermo, with the royal balcony.
From Ćurčić 1987, fig. 6b.

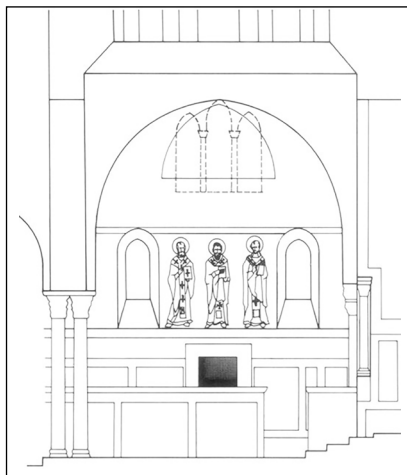


Figure 10
Cross-sections of the Royal Palace and the Cappella Palatina in Palermo; left: three-dimensional model; right: AutoCAD output. The black dashed boxes indicate the 1585 slabs of the modern courtyard (Cortile della Fontana), formerly supported by vaults, which obliterated the original openings on the North side of the Cappella Palatina sanctuary.
Graphic: TecnoArt; © A.R.S. 2015.

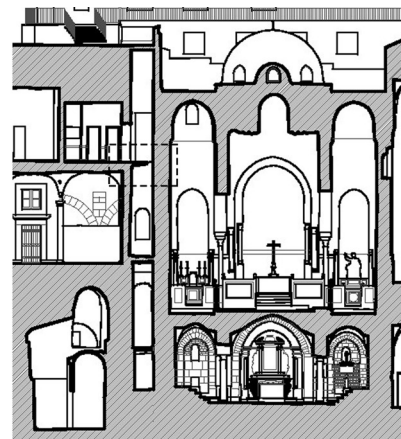


Figure 11
Infrared observation performed on the North wall of the North transept of the Cappella Palatina in Palermo, showing the presence of a walled-up portion of the window.
Graphic: TecnoArt.

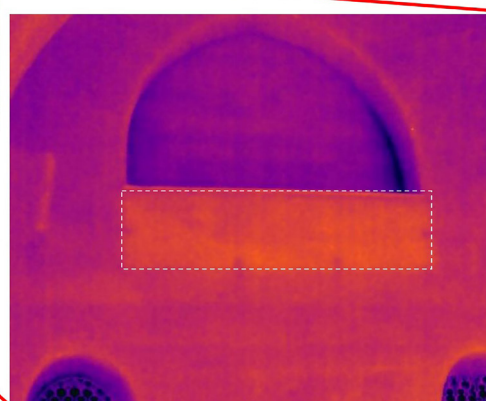
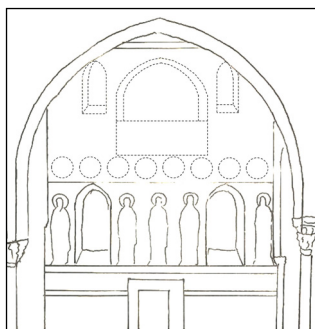


Figure 12
Drawing with the hypothetical reconstruction of the North transept of the Cappella Palatina in Palermo, with the possible original configuration of the royal balcony.
Graphic: Ruggero Longo.



First: the amount of data produced is really high. The dot cloud alone comprises more than two billion points. The datasets are constituted by more than 400 entries, the photographer Gaetano Alfano took more than 2000 pictures, and the total amount of gigabytes produced is extraordinary. This forces us to confront issues of High versus Low resolution. A good compromise would consist in managing multi-resolutions, but the real issue is: to whom do we plan to address our digital model? While addressing these projects to the general public would be democratically important and efficient in promoting culture – and would allow us to opt for lower data resolution in the interest of broader divulgation – I am quite skeptical of the idea that this kind of endeavor could ever be designed for general public only, for our responsibility to convey knowledge would risk to be compromised by a lack of knowledge. In other words, the lower level of detail (resolution) appropriate for a general audience reduces the utility of the model as a tool for advanced interpretation. In order to visualize complexity, we need first of all to understand it; only once we understand it can we have the chance to transform it into ‘simplicity’.²⁷ Therefore, the first aim should be that of creating a powerful tool to investigate and interpret reality, whether current, past or future. But another critical point emerges, concerning resources, funding, and clients. It is clear that to produce an accurate model, we need more resources and time. According to our experience, the government can be an appropriate sponsor for these kinds of investments in cultural heritage, but projects work better if they are not constrained by political agendas, and, of course, if a research center, being it public or private, is the one responsible for project administration, management, and coordination. In 2016, the contents and technologies of the Royal Palace project were

delivered to the Sicilian Regional Assembly, which is responsible for maintenance and public dissemination. Today the model is not available online, for the municipality does not have the capability (and the will?) to manage the firmware updates, software migrations, and other steps necessary to maintain the model and the databases online, and it is even difficult for we, the project’s creators, to use the model. So, the risk is that, in the near future, all of this new digital cultural heritage concerning Sicilian patrimony will be lost.

For my conclusion, I kept some positive points.

First, the importance of designing at a high-definition level is also an answer to another fundamental issue, that of documentation and preservation of cultural heritage in advance of damage or loss. For instance, thanks to the CyArk foundation²⁸ the temple of Bel in Palmyra, Syria, unfortunately lost in recent years, has been virtually reconstructed from tourists’ pictures.²⁹ Unfortunately, once we zoom into the 3D model, the image reminds us that we have lost the primary source of knowledge and every detail of it (fig. 13). Imagine if we had had the chance not only to take pictures but also to perform a HD digital model of this UNESCO world heritage site. Second, we assumed that a 3D model can be considered as a photographic documentation. Unlike, however, an analog snapshot or a printed book, a digital model should be considered not as frozen and static but as alive and dynamic, capable not only to take us traveling into the past but also to follow and document ongoing events, being something incrementable and updateable over the years. In this perspective, digital surrogates should be embraced as one of the most powerful tools for transmitting to the future the present knowledge of the past.

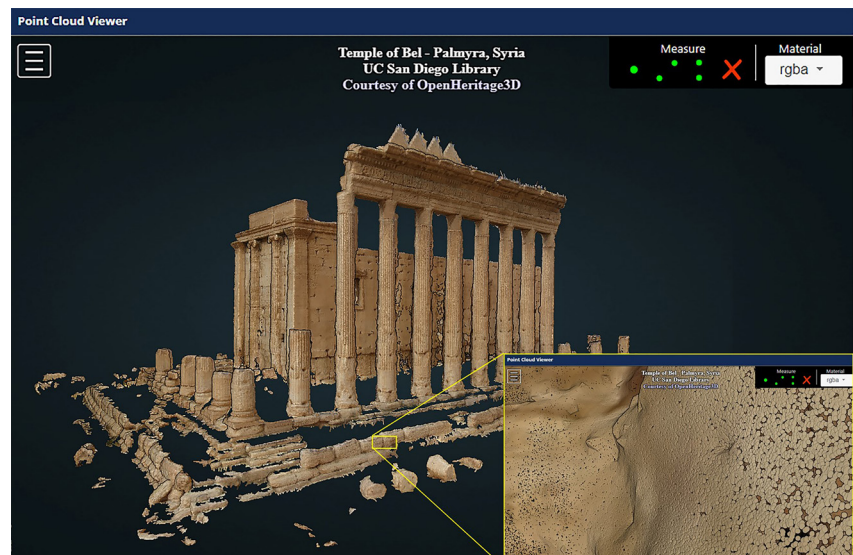
²⁷ Berthoz 2019.

²⁸ <https://www.cyark.org/>.

²⁹ <https://openheritage3d.org/project.php?id=zjnn-wx58>.

Figure 13

Digital surrogate of the temple of Bel, Palmyra, Syria, recreated starting from tourists' pictures. The yellow box shows the low-resolution detail of the surface.
<https://collections.arck-project.org/view/ARCK3D0000000253>; (©) The Arck Project.



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Abstract

Piotr Kuroczyński

Serious 3D in Art and Architectural History

keywords – Digital art history, 3D models, HBIM, 3D Visualization History, Interoperability



The paper delves into the journey and challenges of 3D visualization in art history, architectural history, and cultural heritage. It tracks the origins of computing's impact on linguistics and art history between the 1950s and 1980s. The progress in computing power, CAD software, and graphics led to the acceptance of 3D models. However, doubts arose due to issues like accessibility, transparency, interoperability and reusability. Efforts to establish standards through initiatives such as the London Charter and Seville Principles faced difficulties in practical implementation within the Digital Humanities.

While Building Information Modeling (BIM) thrived in contemporary construction industry, applying it to heritage assets presented unique challenges. This led to the rise of Historic/Heritage BIM (HBIM), catering to the representation of historical structures. Beside the potential of HBIM as flexible object-based information carrier the paper examines the merging of 3D with structured data and the Semantic Web, utilizing tools like ontology for knowledge representation. The importance of critical thinking and epistemology in 3D visualization is underscored.

The paper introduces the concept of the 'Scientific Reference Model', advocating for a standardization in 3D reconstruction of art and architecture and the web-based sharing of 3D models in proprietary and data exchange formats accompanied by structured data. The digital turn and standardization process in civil engineering according the use of 'Serious 3D' is touted as a path toward interoperability and sustainability. The conclusion urges the formal recognition of digital 3D reconstruction as a research

tool and the establishment of 'Serious 3D' models as dedicated research spaces.

DOI: [10.48431/hsah.0210](https://doi.org/10.48431/hsah.0210)

Introduction

The transformational potential of 3D reconstruction for research on historic contexts and cultural heritage is widely recognized but rarely realized. In terms of standards, the field remains the ‘wild-west’ of Digital Humanities, with competing technologies, national research silos, and divergent humanistic approaches ensuring an overall absence of sustainability.

While visualizations of various types have become a staple of the Digital Humanities approaches deployed in art and architectural history, a fundamental concern for researchers remains how analogue data, like artworks and drawings, archival documents etc., can be integrated within such born-digital research outputs. Without embedded and transparent metadata, these outputs struggle to gain acceptance as valid vehicles for research alongside conventional peer-reviewed articles and books, and the opportunities offered by these digital tools lie dormant in humanities research.

The issue is especially pronounced in the field of 3D modeling where there are, as yet, no comparable common standards for creating models or integrating underpinning data within them. The need for shared protocols is becoming more pressing as tools and practices associated with modeling technologies are increasingly deployed to a range of art historical visualization projects focused on specific places and eras. It is this need that can be addressed only through an integrated and collaborative approach that draws on the research expertise of an interdisciplinary community and the emerging solutions and

standards in ‘serious’ industries concerning 3D and data engineering/modeling.

3D Visualization and Art and Architectural History

Interest from the humanities in computing as an aid for data processing and analysis (especially in linguistics) was already evident in the 1950/60s,¹ but significant engagement by art history dates from the 1980s, driven by the needs of image and object classification projects, especially those promoted by the Getty Foundation.² An important role was played by the iconographic indexing of image collections in a formalized, computerized language and the emergence of controlled vocabularies.³ With the development of digital images and computer graphics (especially CAD software), the increase in computing power, and the spread of PCs, the first attempts at computer-assisted visualization in object-based research caused a sensation from the mid-1980s on. Early projects like the 3D reconstruction of Westminster in the UK or Cluny III in Germany pioneered what would become, by the 1990s, a boom in digital 3D reconstruction projects,⁴ with an ever-increasing demand for computer-generated 3D models.⁵ The history of art and architecture recognized early on the potential of computer-aided 3D reconstruction and the digital 3D model. The undeniable advantages of the 3D digital over the 2D analogue approach include the holistic view, the stronger spatial reference, as well as the increase in interpretive power and knowledge resulting from 3D modeling and visualization.⁶

The advent of the Internet – and the increased engagement with 3D modeling it engendered

1 Bowles 1967.

2 Pratschke 2018.

3 Heusinger 1983.

4 Reilly 1991.

5 Messemer 2016.

6 Favro 2012.

– saw the emergence of critical reflection on the part of art and architectural historians regarding computer-generated visualization and the relationship between digital and analogue research outputs. Already in 2001, Hubertus Günther recognized that access to an unprecedented number of publications would often not be useful for traditional research and that the 3D model in connection with a database (here still understood as a separate software application) would constitute a significantly more effective form of publication or access to the research object.⁷ Günther's predictions have been amply born out over the subsequent two decades. The quantity and complexity of data now generated by humanities research is testing the limits of analogue print publication. Even at building-scale, monographic publications often extend to multiple volumes, an increasingly uneconomical model with no potential for revision or integration of new research data.⁸

Also in 2001, Stephan Hoppe used the Altenberg Cathedral project to show the potential of the 3D model as an interactive knowledge space and introduced the idea of a “digital footnote of the model.”⁹ *The Virtue of Models: CAD and the new spaces of art history*¹⁰ conference in 2000 and the resulting publication raised hopes for the new medium at the same time as identifying outstanding challenges for the application of 3D modeling and visualization as a working tool and methodology in the history of art and architecture.¹¹ The lack of transparency regarding primary sources, the interpretation of those sources, and the modeling process itself led to widespread skepticism within object-based disciplines, reinforced by lack of access and interoperability. Practice fell far short of recommended scientific practice,¹² and fostered a negative impression of 3D models as an ‘unserious’ field in terms of scientific research that persists today.

EU projects such as EPOCH, Carrare, and 3D Icons addressed these challenges, giving rise to the London Charter¹³ of 2006, the most widely-cited call for standards and best-practice in the field. The Charter argued that 3D visualizations should incorporate their underpinning data and also the processes used in their own creation, introducing a new concept of paradata for creative interpretation alongside the existing understanding of metadata. However, both the London Charter and its successor, the 2011 Seville Principles,¹⁴ were unable to establish workable solutions, and their impact has been largely aspirational, raising awareness of continued shortcomings. There is still no consensus regarding technical and methodological approaches, and little agreement on standards for their implementation. As compared to progress made in 2D with IIIF, the 3D visualization of cultural heritage remains the ‘wild-west’ of digital humanities in which lack of transparency results in models that “only convey a small percentage of the knowledge that they embody” and are “highly resistant to peer review.”¹⁵

3D Visualization and Civil Engineering

At this point, it is worth looking over the disciplinary boundary wall into the neighboring fields of the object-related engineering sciences and their handling of 3D modeling, which trace their origins back to the emergence of computer graphics in the 1960s. IT-supported automation using digital 3D models was pioneered in mechanical engineering. As early as the 1980s, standardized data exchange formats in the 3D field (STEP)¹⁶ were agreed, triggering pushes towards digitization (notably, for example, in the automotive industry), which brought substantial increases in productivity. In this arena, the ‘seriousness’ of the 3D

7 Günther 2001.

8 Even a well-funded analogue project like Die Kirchen von Siena, supported by the Max-Planck-Institut: Kunsthistorisches Institut in Florenz, was abandoned in 2012 having only reached the letter ‘D’. See: <https://www.khi.fi.it/de/publikationen/die-kirchen-von-siena/>

[index.php](#).

9 Hoppe 2001.

10 German: Der Modelle Tugend – CAD und die neuen Räume der Kunstgeschichte.

11 Frings 2001.

12 DFG 2019.

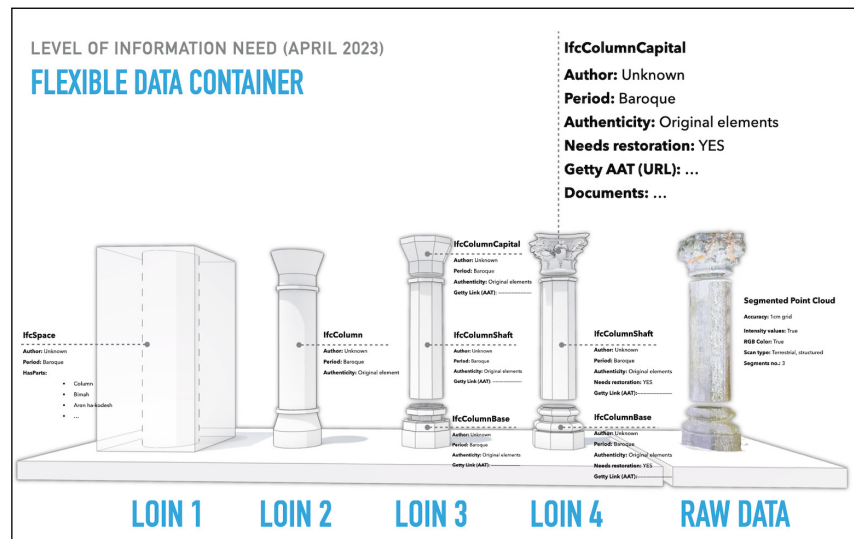
13 Denard 2012.

14 Bendicho 2013.

15 Bentkowska-Kafel/Denard/Baker 2012.

16 STEP project initiated 1984 by Iso Tc184 “Industrial Automation systems and Integration” Sc4 “Subcommittee “Industrial Data”. See: <https://studylib.net/doc/9975286/history-of-step>.

Figure 1
Definition of different Levels of Information Need according the column of the Bimah, Synagogue in Przysucha (Poland).
AI MAINZ, 2023 | Piotr Kuroczyński and Karol Argasiński (CC BY-NC-SA).



models is founded on object-based 3D modeling, which can be enriched with alphanumeric information. The 3D model represents a digital twin of the real object as a modeled solid (object-based) with its properties (information) embedded. The standardized 3D data exchange format guarantees effective, interdisciplinary collaboration and minimizes information loss in the development and production processes. Since the late 1990s civil engineers have sought to catch up with their mechanical engineering peers in order to drive digitization in civil and urban engineering as well as long term building operation (smart buildings) and urban management (smart cities).

In the construction industry, the term Building Information Modeling (BIM) for a collaborative planning method using the Industry Foundation Classes (IFC) data exchange format has been gaining acceptance since the mid/late 1990s. In regional and urban planning, City Geography Markup Language (CityGML), a data exchange format for storing and exchanging 3D virtual city models, has come to dominate over the past two decades. Digital 3D models can occur in different Levels of Information Need in BIM/IFC¹⁷ or Levels of Detail in CityGML¹⁸ depending on the project phase or the degree of elaboration. In addition to geometry and appearance, the semantics (meaning) and topology (relationships) of the objects are also described

regarding the project specifications defined in the “Employer’s Information Requirement” (EIR). The EIR is an important element of a Project BIM Implementation and is used to set out clearly to the Project Team or Supplier what information (models, documents and data) is required generally and at each project stage.

While BIM applications in construction are well-documented (Penn State University, 2013)¹⁹, the absence of standardized international workflows for integrating these advanced techniques with Cultural Heritage Assets persists. Standardizing Cultural Heritage (CH) metric documentation and Heritage/Historic Building Information Modeling (HBIM) presents challenges, as each CH asset requires distinct information across its lifecycle, encompassing physical and intangible attributes like history and culture. Tasks involving CH, such as knowledge acquisition and restoration, demand specific data inputs. Though guideline books offer general proposals, they merely represent initial standardization efforts.²⁰ Consequently, HBIM has emerged as a novel scientific field focusing on digitally representing CH assets. Ongoing research evaluates methods and templates for standardized procurement workflows, streamlining documentation of historic structures and heritage assets while cooperating with preservation authorities.²¹ Utilizing diverse measurement techniques, registering point

¹⁷ Luedy et al. 2021.

¹⁸ Biljecki/Ledoux/Stoter 2016.

¹⁹ Penn State University, 2013. BIM Uses.
<https://bim.psu.edu/uses/> (accessed on

12.08.2023)

²⁰ Antonopoulou/Bryan 2017.

architecture. A comprehensive overview on the use of digital 3D technologies in the humanities is given by Münster in his postdoctoral thesis.²⁴ The use cases which incorporate human- and machine-readable documentation includes projects from archaeology using the Games Engine, such as the Oplontis project,²⁵ and from art history, such as the documentation of the reconstruction processes (paradata) of the Zwinger palace in Dresden in the DoKuVis project (Bruschke and Wacker, 2016)²⁶ and the documentation of the transformation of the old town of Nuremberg in the TOPORAZ project.²⁷

Special mention needs to be made here of the leading role of the project at the Herder Institute for Historical Research on East Central Europe in developing the first CIDOC CRM referenced application ontology for mapping underpinning sources and the processes involved in the 3D reconstruction of royal castles in the former German territories of East Prussia (Kuroczyński/Hauck/Dworak 2016). As a result, a Virtual Research Environment (VRE) developed in the DFG infrastructure project (WissKI)²⁸ was adapted for the documentation of 3D reconstruction projects and the prototype presented for a web-based Virtual Museum.

The experiences from the project on royal castles were further developed at the Institute of Architecture at Mainz University of Applied Sciences. Here the use of BIM was evaluated for the art and architectural history examination of the 1938 destroyed New Synagogue in Breslau, in present day Wrocław (Poland), in conjunction with a VRE and an adapted application ontology. The project provided new insights regarding the requirements for object-oriented 3D modeling, alphanumeric information storage including the BIM internal classification system, and the use of controlled vocabularies and authority files.²⁹ In parallel, the same approaches were applied to 3D reconstruction documentation of the mediaeval cities of Mainz, Worms, and Speyer, exhibited in a Digital Urban History Lab at the Landesmuseum Mainz.³⁰

This preliminary work took particular account of the requirements of good scientific practice, especially with regard to documentation, but also flagged fundamental questions about object-based 3D modeling and the seriousness of the research data generated in light of the FAIR Principles proclaimed in 2016.³¹

An Epistemology of 3D Visualization

The proceeding discussions pushed by *The Virtue of Models* conference and the emerging community, here decisively represented by the Working Group Digital 3D Reconstruction³², also highlighted the importance of critical reflexivity, drawing attention to the epistemological implications of digitizing, modeling, rendering, and reconstructing art historical objects and architectural spaces, and how these sit within art history's established practices of critical interrogation of media.³³ Digital visualization invites us to consider how the materiality of objects is handled in the 3D model and to acknowledge the agency of aesthetics (in the sense of design) in the modeling process. Critical analysis helps us to deconstruct the models' seductive promise of reality, while prompting us to reconsider our established research questions and the very ways we do research. As we reflect on the model and its underpinning data, so we are obliged to rethink the way evidence is assembled, and the heuristics of our disciplinary practices.

A model is a research environment for testing data and reflecting on the certainty of hypotheses derived from the interpretation of data, while also serving as an invitation to consider complexity, varieties of interpretation and the risks associated with the compelling visual presentation of a photorealistic reconstruction. This capacity for critical reflection is often lacking in Digital Humanities work, but within an interdisciplinary framework provides an essential foil to the positivist language routinely deployed in engineering fields, where – to cite one telling instance – a BIM model is often

24 Münster 2022.

25 Clarke 2016.

26 https://www.researchgate.net/publication/333748194_DokuVis_-_A_Documentation_System_for_Digital_3D_Reconstructions.

Reconstructions.

27 Razum et al. 2020.

28 <https://wiss-ki.eu/de>.

29 Kuroczyński/Bajena et al. 2021)

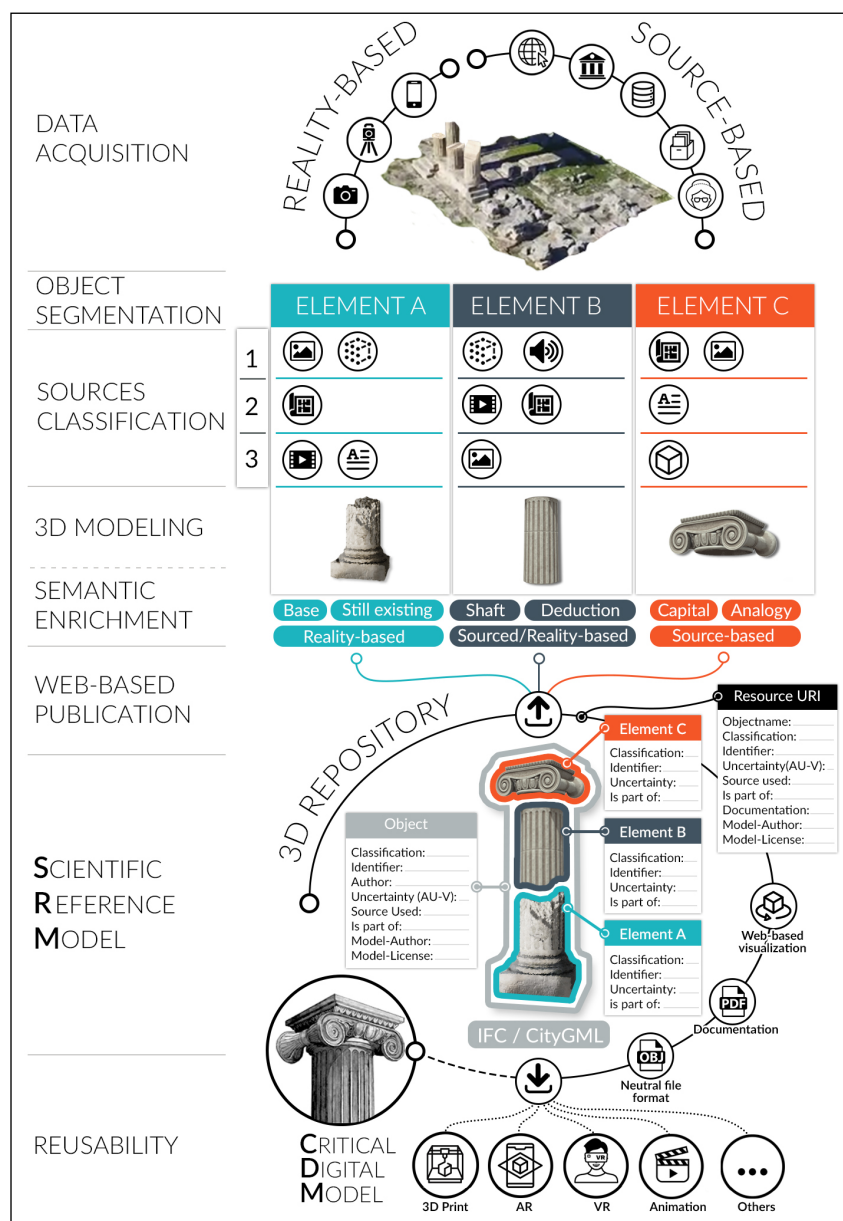
30 Kuroczyński/Bajena/Große 2023.

31 Wilkinson et al. 2016.

32 <https://digitale-rekonstruktion.info/>.

33 Kuroczyński/Pfarr-Harfst/Münster 2019.

Figure 4
Data-driven Scientific Reference Model and its derivatives. An overview.
AI MAINZ, 2023 | Piotr Kuroczyński and Igor Piotr Bajena (Cc By-Nc-SA).



termed a 'Single Source of Truth'. A source that holds a generally valid data set of the project and that claims to be accurate. One can rely on the fact that this data is correct. Information about the data (metadata and paradata) provides the user with information about how the data was obtained (data quality) and thus increases the validity of the data.

Scientific Reference Model

The special significance of the 3D model in the context of construction industry is based on the desire to efficiently overcome the

greatest challenge of the construction site, namely communication, by means of object-related information. The so-called integrated coordination model becomes the working and communication medium in the planning and construction process and ultimately the digital twin of the building in the operation phase. If we transfer this basic idea behind the digital planning method BIM to the requirements of object-oriented research, we can speak of a Scientific Reference Model (fig. 4), which can become the object of communication and discussion and subsequently become a research space itself. The basic assumption of the

Figure 5
Section of the Scientific Reference Model
'Olkieniki Synagogue': IFC file in Bimcollab viewer.
AI MAINZ, 2023 | Igor Piotr Bajena (Cc BY-Nc-SA).

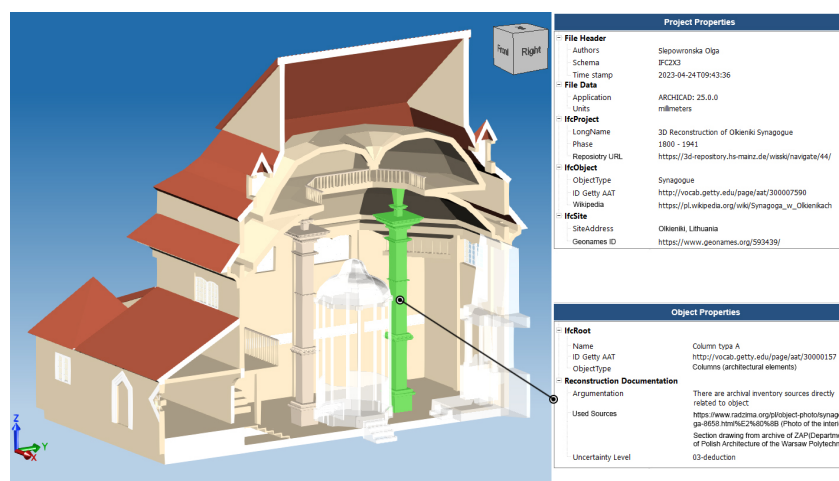
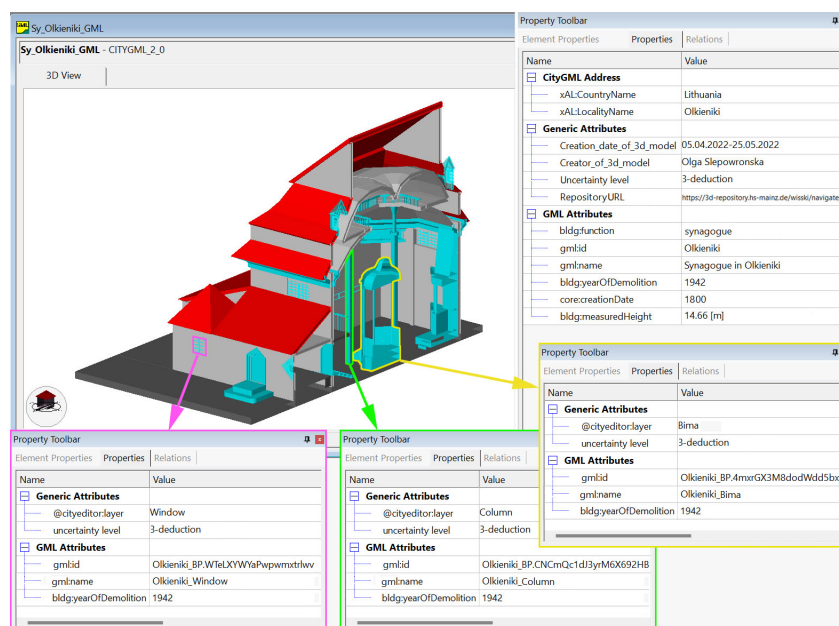


Figure 6
Section of the Scientific Reference Model
'Olkieniki Synagogue': CityGML File in Fzk viewer.
AI MAINZ, 2023 | Irene Cazzaro (Cc BY-Nc-SA).



Scientific Reference Model is the need to establish a standardized working method that ensures flexibility, sustainable provision, findability, interoperability and reusability (in Edition).³⁴

According to the concept, the Scientific Reference Model is fulfilled only when a 3D model resulting from a research project is made available online in standardized data exchange formats accompanied by structured human- and machine-readable metadata and paradata. For this purpose, the data exchange formats of BIM/IFC and CityGML mentioned above are suitable, which, depending on the specific project requirements, incorporate different degrees of elaboration with regard to the geometry and the stored information.³⁵

Thereby, the great advantages of a flexible handling of the information in the 3D models can be used efficiently (cf. fig. 1). Depending on the defined Level of Information Need, the model can meet the different requirements of the research projects. By using established and standardized formats, the model can be shared, and further used independently of the software and across disciplines (fig. 5, fig. 6). The raising of awareness with regard to a common working method in the sense of the Scientific Reference Model and the resulting provision of the work results strengthens the seriousness of the 3D models in the direction of the acceptance as 'valid vehicles for research' postulated at the beginning.

³⁴ Kuroczyński/Bajena/Cazzaro, forthcoming.

³⁵ Kuroczyński et al. 2023.

Conclusion

The above-mentioned concerns with standards, transparency, uncertainty and sustainability were caught up at the international conference *Visualizing Complexities: Practices and Heuristics of Digital Models in Art History*³⁶ in Rome in December 2020 and were refined in the conference *The Future of the Virtual Past: New Directions and Shared Standards in the Reconstruction of the Medieval-Renaissance Built Environment*³⁷ in Cambridge in June 2022.

Discussion at the Cambridge conference cemented the consensus that BIM, and more especially its historical/heritage extension HBIM, represented the best pathway towards sustainable standards and potential interoperability across academic research and the cultural heritage sectors. It sharpened the focus on 'Serious 3D' with the capacity to go beyond the digital conservation and documentation of extant structures, to encompass the modeling of non-extant structures, and the integration of building-scale and object-scale data with attendant para- and metadata, acknowledgment of uncertainty and hypothesis.

Our discussions parallel a series of infrastructure projects at national level currently under development, like Consortium for Research Data on Material and Immaterial Cultural Heritage (NFDI4Culture)³⁸ and the Specialized Information Service BAUdigital³⁹ in Germany. The national efforts meet the requirements of the scientific community regarding the 'New Data Culture' proclaimed by German Council for Scientific Information Infrastructures (RfII)

"Ensuring sufficient data quality over the entire data life cycle requires a joint effort. Each of the producers, processors, and various reusers of research data must assume responsibility for ensuring the quality of the data. This requires a new culture of open data and data sharing, but also agreements on standards."⁴⁰

It is now time to define the digital 3D reconstruction as a research method and introduce the digital 3D model as an established research space. The idea behind the Scientific Reference Model and the resulting Serious 3D for art and architectural history provides an important step and is currently being explored at five universities within the European project 'Computer-based Visualization of Architectural Cultural Heritage' (CoVHer).⁴¹

Acknowledgements

The following article is based on a proposal submitted to the UK-German Funding Initiative in the Humanities (AHRC-DFG) under the same title in February 2023 in collaboration with Donal Cooper (University of Cambridge) and Fabrizio Nevola (University of Exeter). Thus, I would like to thank the colleagues from the United Kingdom for their good cooperation, further hints, and some eloquent formulations. Furthermore, I extend my gratitude to Tanja Michalsky and Elisabetta Scirocco from the Bibliotheca Hertziana - Max Planck Institute for Art History for inviting me to participate in the Rome 2020 conference, which provided an excellent setting for further discussions and the starting point for the Cambridge conference in 2022.

³⁶ <https://www.biblhertz.it/3051429/visualizing-complexities-practices-and-heuristics-of-digital-models-in-art-history.html> (accessed on 12.08.2023).

³⁷ https://www.academia.edu/81679396/The_Future_of_the_Virtual_Past (accessed on 12.08.2023).

³⁸ <https://nfdi4culture.de/>.

³⁹ <https://www.fid-bau.de/en/>

⁴⁰ Enhancing Research Data Management 2016 <https://rfii.de/download/rfii-recommendations-2016-performance-through-diversity/>.

⁴¹ <https://covher.eu/>.

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