Digital Translations of Paper Architectures

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Abstract

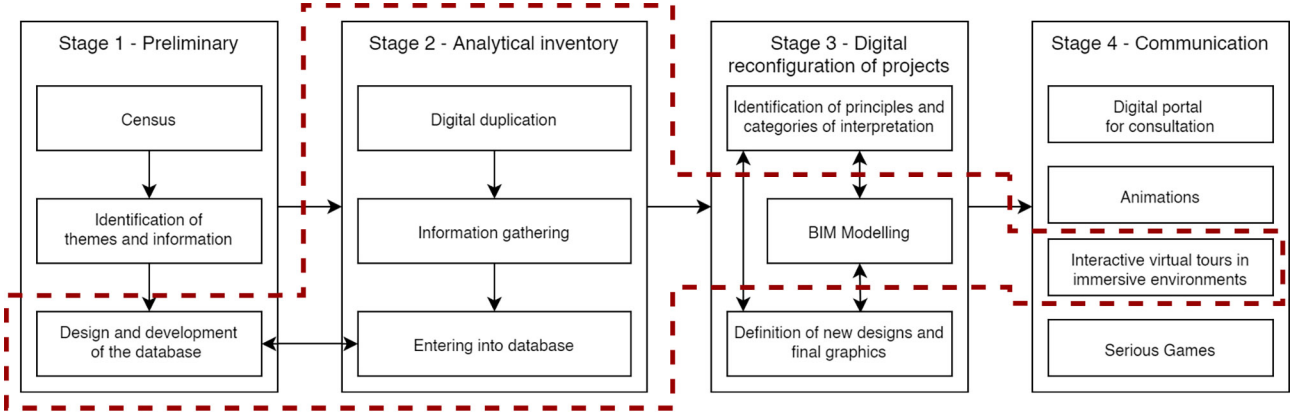
The digitization of architectural archives has opened an evaluation on the contributions that the digital medium can provide in the production, consultation and dissemination of the archival heritage. The Department of Environmental Civil Engineering and Architecture (DICAAR) of the University of Cagliari holds a large collection of drawings and photographic materials that testify the didactic activity of the School of Architecture and reveal the names of generations of architects and engineers trained in Cagliari. Studying and preserving this heritage means first conserving and transmitting the memory of the school in Cagliari, but also exploring new ways to investigate and communicate the hidden meanings of drawings on paper. The paper analyzes the development of a workflow aimed at the digitization, enhancement and dissemination of project drawings carried out by 41 students at the Royal University of Cagliari to be declared a Civil Architect. Made under the supervision of Gaetano Cima, one of the most important figures in the culture of nineteenth-century architectural and urban design in Sardinia, the 41 projects offer the opportunity to investigate the potential of the digital medium in the construction of personalized and multimedia knowledge paths. Through the definition of narrative segments, the study is oriented towards the construction of an archive that becomes a virtual museum, capable of accompanying the public in the 'visit' of never built architectures.

Keywords: architectural archives, paper architectures, Gaetano Cima, BIM, VR.

Introduction

With the advances in the world of technologies for the communication of cultural heritage, archives have taken on an unprecedented role with an enlarged audience that is no longer just that of expert users. Today the archives try to give answers to the growing demand for generic seekers who are guided and accompanied in consulting the databases thanks to the tools of the digital medium. The new interest shown by the general public has forced a reflection on the functions to which today an archive must and can perform. Online inventories, digital reproductions, research guides to navigate the documentary system of the archive are some of the most popular tools among the structured resources normally offered to remote users. But the digital medium is certainly not sufficient to guarantee an effective digital migration of knowledge and the traditional archival tools made available remotely sometimes prove to be lacking, especially in relation to the descriptions that often prove not very usable and effective for users [Alfieri, Feliciati 2017]. Today we are all aware that, in the enhancement of documentary heritage, it is no longer sufficient to offer the description of archival collections and producers through guided research tools on predefined themes and paths. The consultation should present the heritage allowing the construction of personalized paths of knowledge by proposing different levels of analyticity. Archives accessible remotely have so far experienced the transition to digital mainly in terms of purely quantitative extension of the materials made available online, leaving in the background the advan-

Fig. 1. Workflow for the digitalization and communication process of paper architectures [graphic elaboration Raffaele Argiolas, scientific coordinator Vincenzo Bagnolo].



tages that ICT (Information and Communication Technologies) can give not only in terms of remote access to documents but also in terms of "cognitive accessibility" to the multiple latent information inherent in the different types of documents. If this is generally true for all types of archives, undoubtedly the strength of the digital medium and of the possible reconfigurations manifests itself even more effectively for architectural archives [Armstrong 2006; Chiavoni, Diacomitri, Di Pietro Martinelli 2019; Palestini 2017; Vernizzi 2020; Willis 1996].
The adoption of new languages that take advantage of ICT both in production, with the construction of a range of information that is increasingly expanding, and in consultation, with diversified dynamic research paths, can allow a digital migration of the documentary heritage that amplifies relations with the public. The documentary heritage of the archives is no longer just something to be preserved and described but something to be 'exhibited' by weaving a 'narrative'. Feeding on a wide range of possible interactions, the remote visitor today is eager to build his own itinerary of knowledge. By avoiding exceeding in interpretations that undermine the path of knowledge transforming it only into a technological circus, at times the research can also disregard the hierarchical descriptions of the documentary units.
The 3D modeling process, implemented in digital archives with a process of reading and interpreting the paper design, reveals those meanings of architecture, often hidden even from the expert eye, that the public is unlikely to appreciate. The narration, as well as according to the two targets 'expert seeker' and 'casual seeker', can also be declined according to characterizing thematic sectors structured according to the different age groups, with not only informative but also didactic purposes.
The DICAAR, Department of Environmental Civil Engineering and Architecture of the University of Cagliari, houses a large collection of didactic tools used in the teaching of Drawing. Photographic collections of architecture, plaster casts, physical models and drawings tell the story of the didactic activity of the disciplines of drawing at the University of Cagliari in a period between 1843 and the 1970s, providing valuable evidence on academics training in this time frame [Chiavoni 2014].
In the study of a varied and articulated whole such as the DICAAR collection of drawings, it was decided to start with a first census of the architectural design drawings of the nineteenth century. The digital reproduction of paper drawings and the collection of some information directly related to the description of the individual architectural projects are the first steps in building a database. The database is designed to load not only a drawing section but also other different sections dedicated to all the other teaching tools for drawing kept at the DICAAR, as in the case of the collection of plaster casts which played a fundamental role in the exercise of the design for the training of architects [Bagnolo, Argiolas, Cocco Bellumori 2021].
For 19th century projects, among the documentation accompanying the digital raster reproductions of the draw-

ings, it was decided to include also some digital models that help to document, study, represent and communicate the reasons for the project and its results.
A first phase of the research aims to identify and define some key points for understanding and communicating the so-called 'paper architectures' in a digital environment. To test the database of the 'drawings section' and identify the categories of information to be associated with the documents, it was decided to build a workflow starting from the study of a selection of design documents. Graphic analysis of geometric and compositional matrices, critical interpretation, cognitive accessibility, 3D modeling, application of VR systems to AR and a web strategy to be adopted are just some of the possible approaches that must be part of the workflow (Fig. 1). This strategy is in line not only with the new research and dissemination needs of the scientific community but also with the demand of a wide audience.
The research aims to explore the potential of some categories of digital tools which at the same time can lead to two objectives: the construction of meanings strictly connected to the case study of the School of Gaetano Cima and some possible reconfigurations in the ways of enhancing and communicating architectural archive drawings.
The workflow is outlined through the study of the drawings selected between the 41 architectural projects for the final exam of Civil Architect taken by the students of Gaetano Cima (Figs 2-4). This is a project from 1859 which is divided into 5 tables, 4 of which are on a scale of 1:200: the drawing of the main facade (Fig. 2), the drawing of the general plan (Fig. 3), the drawing of the floor plan of the upper level in scale 1:100, the drawing of the longitudinal section (Fig. 4) and finally the drawing of the cross section. The 41 projects of the students of Gaetano Cima allow us today to investigate the architectural project design under many aspects: in the particular form of graphic drawings developed for a final examination, which today we could define as Thesis, in the role of design project of neoclassical architectures, in the reading of the characteristics of the is-

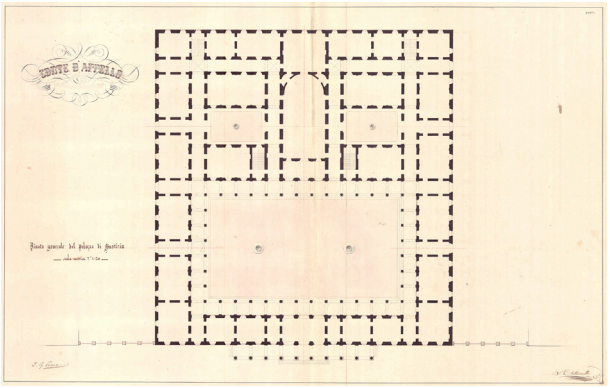


Fig. 2. Luigi Arthemalle Persi. Court of Appeal, drawing of the main facade of the building in the metric ratio 1: 200.

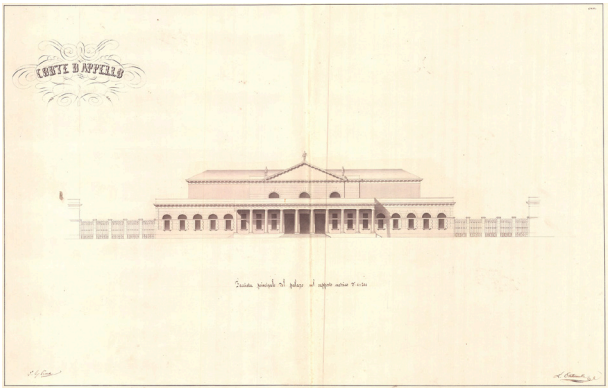


Fig. 3. Luigi Arthemalle Persi. Court of Appeal, drawing of the general plan of the courthouse, metric scale of 1: 200.

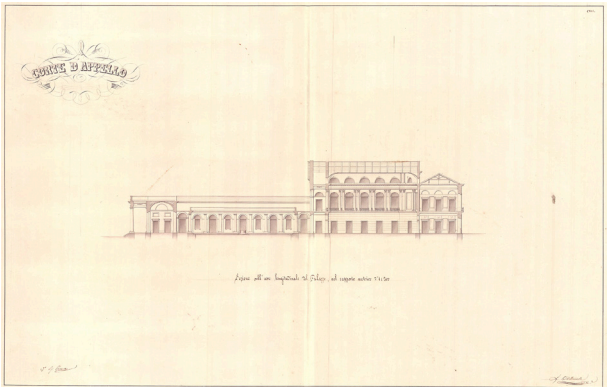


Fig. 4. Luigi Arthemalle Persi. Court of Appeal, longitudinal section of the building in the metric ratio of 1: 200.

land's architectural culture imparted by Cima in his teaching, in the critical reading of the graphic and compositional aspects of the projects, in the analysis of geometric matrices and in the possible 2D and 3D digital reconfigurations.

The pupils of Gaetano Cima

Gaetano Cima is certainly the most important exponent of nineteenth-century architectural and urban culture in Sardinia Born in Cagliari in 1805, he became a 'civil architec' at the Faculty of Sciences and Letters of the University of Turin where he studied between 1826 and 1830 as a pupil of Ferdinando Bonsignore. In the following three years he perfected himself at the Accademia di San Luca in Rome. Back in Sardinia, he began to work for the Genio Civile until he became Chief Architect of the city of Cagliari [Del Panta 1983]. His experience as a university professor began in 1840. In 1863 he was confirmed full professor of architectural drawing, becoming dean of the Faculty of Physical, Mathematical and Natural Sciences of the University of Cagliari. He died in 1878. If the figure of Gaetano Cima as architect and urban planner is well known [Del Panta 1983; Sanna 1996; Serra 1995], the same cannot be said about Gaetano Cima's role as professor at the University of Cagliari and his teaching activity [Masala 2002a; Masala 2002b].
The drawings made by 41 students of the Royal University of Cagliari at the end of their studies to be declared a "Civil Architect" correspond to 41 projects now kept in the Disegno section of the DICAAR. By addressing and developing some typical themes of nineteenth-century architectural and urban culture, these projects testify to the profound economic and social transformations of the time.
The 41 'Theses' offer a unique opportunity to study a body of projects carried out between 1843 and 1864 and to deepen the knowledge on the academic training of the students of Gaetano Cima. Among the drawings we find mainly the projects of large public buildings and some representative residences that enhance the functionalist aspects of nineteenth century 'rationalism'. Cima assigns to his students a series of buildings destined among other things to library, theater, stock exchange, school, public archive, town hall, court, bank, orphanage, hospice for the poor, meteorological observatory, or botanical garden to name a few [Bagnolo 2011]. The final exam for Civil Architect involved the design of a project to be developed on a theme assigned by Gaetano Cima.
Cima himself in 1852 in his notes kept at the Historical Municipal Archives of Cagliari (Archivio Storico Comunale di Cagliari - ACC), in relation to the program of his lessons, writes that the students of Architecture, after having received the approval in the third year exam, must take a public experiment on all the subjects taught in it and on the composition of an architectural project, with related drawings, calculations and written dissertations, according to the theme proposed, a few months before, by the professor to each of the candidates [A.C.C., Carte Cima, No.26].
The 41 projects are accompanied by the original text of the theme dictated by Cima with precise indications on aspects such as the geometry of the building, the morphology of the site, the principles and architectural models of reference, the level of richness of the decorations. In the indications given by Gaetano Cima, the description of a design theme expressed both from a formal and substantial point of view reveals the "*caractere convenable à chaque genre d'édifices*" [Blondel 1771, p. 318].
The historical-cultural context of the 41 projects and their nature of design proposals for important public buildings and residences, led to the choice for an expansion of the database structure with the integration of BIM models.
In addition to the advantages made possible thanks to the immediacy of the graphic coding of 3D visualization, the integration of BIM models offers several advantages in the modeling procedures and in the communication of projects.
To test a workflow, the study of a sample of projects allowed the selection of formats and standards of digital models. The examination of the projects began with the identification of one of the 'Theses' to be used as a model for the development of the workflow. The construction of the BIM model allowed an initial verification of the hypotheses made regarding the choice of the digital modeling environment [Spallone 2016; Spallone, Natta 2022], with the subsequent implementation of a virtual tour in immersive environments [Osello, Lucibello, Morgagni 2018].
The chosen project is the theme proposed to the candidate Luigi Arthemalle Persi for the public examination of Civil Architecture on 13 October 1859 (Figs. 2-4). The theme assigned to Luigi Arthemalle Persi envisages the design of a Court of Appeal whose main façade overlooks a rectangular courtyard surrounded by architraved peristyles and rooms for the guardhouse and minor offices. Cima defines all the different functions of the rooms of the building, providing precise indications on the maximum dimensions of the fronts, on the size of the surfaces, on the number of floors, on the difference in level of the ground. A prostyle decastyle on a base

of seven steps adorns the external front and leads to the primary vestibule. The main hall, with galleries around it, is placed in the middle of the building, rising with a double height; the width should be eleven meters, and the length should be one and a half greater than the width, not counting the radius of the grandstand that is on the side opposite the entrance. Cima also emphasizes the character that architecture must communicate: the solidity of the construction and the choice of decorations help to excite the concept of stability and equality of laws, and the patronage that it offers to every class of citizens. The robustness of the architectural order, the simplicity of the right symmetries, must express the idea of a sanctuary of justice entrusted to the care of upright and wise magistrates [Archivio Disegni DICAAR, Allievi Cima, n.26].

The database

In order for information to be exchanged effectively, it needs to be organised and classified by means of shared and understandable encodings; this makes it possible for the same data to be used by users with different skills and purposes [Schweibenz 2019]. In the digital sphere, one of the most widely used data structures is undoubtedly that of databases, particularly relational databases, in which information is organised in tables linked together by means of data relations, allowing targeted searches by setting filters or search parameters. The development of a relational database is therefore one of the most logical solutions for cataloguing, archiving and subsequently communicating information, whether extracted from the original documents or resulting from subsequent processing; this also allows dialogue between the database containing the general information and the BIM models to be generated, thanks to the organisation of the latter in databases. The structure of the database is schematised in Fig. 5. Consultation of the database takes place by means of query cards in which it is possible to view the main information relating to the individual works, enter new information or carry out searches. Each sheet is formatted according to the type of element displayed, and in the specific case of the works by Cima's students, information is available on the author, the physical support, the technique used and so on [Chiavoni 2014]. As it can be noticed, inside the database there are data related not only to the final elaborations of Cima's students, but also regarding other materials in possession of the Drawing Laboratory of the Faculty of Engineering and Architecture of Cagliari; among these there are photographic and video materials, the elaborations produced during the years in the Drawing courses or even the plaster casts used for teaching purposes purchased by the Laboratory at the beginning of the last century [Bagnolo, Argiolas, Rocco Bellumori2021a]. Similarly to what is foreseen for the plaster casts, also for the drawings of Cima's students the database foresees the insertion of links to digital elaborates and in particular to 3D models; in the case of the produced BIM models, their consultation can be structured through HTML pages specifically developed for the visualization of IFC models that, directly exported from *Revit*, contain univocal IDs that would allow the exchange of data between *Revit* model, database/archive and web interface.

BIM modeling for paper architectures

3D modelling of designed architecture provides the possibility of considerations and studies that would be difficult to achieve with the analysis of 2D drawings in paper form alone, allowing new studies of spatiality or building coherence. Digitisation, and in particular the modelling of a project starting from the paper, thus excluding a design intervention, has as a fundamental requirement the interpretation of the drawings according to a logic not dissimilar to that used in the survey of the built environment. The design choices and the techniques used to implement them are analysed and validated to produce drawings that tell the story of the architecture surveyed.

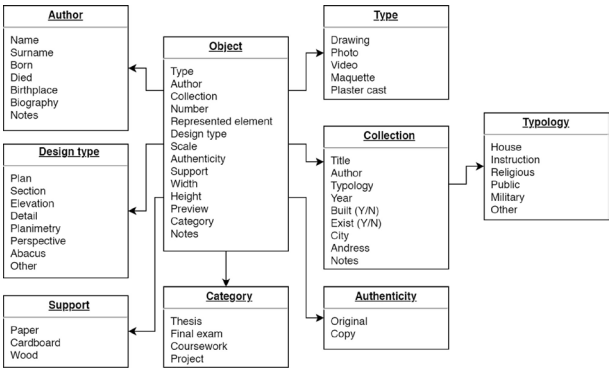


Fig. 5. Structure of the paper architectures database [graphic elaboration Raffaele Argiolas, scientific coordinator Vincenzo Bagnolo].

While this is true for classical modelling, there are tools that can expand these possibilities by parallel modelling of both geometric and physical-constructive information.
In this sense HBIM processes, and in particular their practical implementation called Scan-to-BIM, are of increasing interest for the collection and management of information related to historical heritage. The so-called 'as-built' approach, however, cannot be applied to architecture on paper, if not through a change of paradigm; while the need for a conscious and interpretative reading remains unchanged, a further step must be taken when the information gaps cannot be filled for obvious reasons through a direct reading of the built architecture.
Recent researches analyze and demonstrate how HBIM processes, if properly applied to architectural drawings, can offer interesting potentialities for their analysis and communication [Spallone,Natta 2022]; in this contribution the potentialities of HBIM in terms of digital reconfigurations of architectures on paper aimed at the generation of elaborations necessary for the understanding of the architectures but not present among the original documentation are addressed. In the specific case of the final works of the Cima students, united by the school to which they belong, the BIM methodology, based on the use of 'families' of reusable elements allows the identification of possible invariant objects within more than one project.
Another important advantage of using BIM is the possibility of associating each object with an attribute indicating the level of deduction required to model the object.
Notwithstanding the potentialities exposed by the BIM methodology, the use of BIM software still requires that these are supported by other tools for a better expressive and graphic management, aspects that often transcend the normal BIM logic.

The BIM model

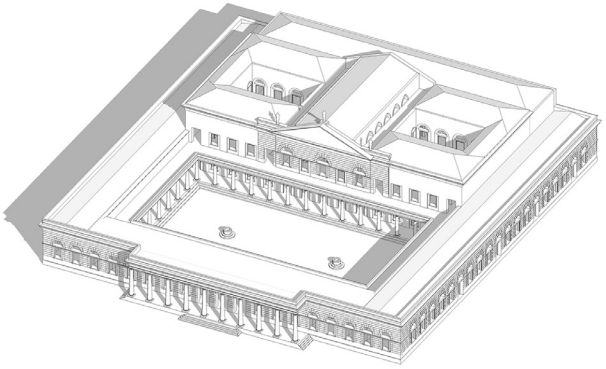
As we know, in the approach called HBIM [Murphy 2009], the development of the intelligent model comes after an initial and fundamental phase of research and critical reading of archival and design sources. The modelling is based on geometric information extracted from point clouds obtained through survey methodologies of the existing such as laser scanning and photogrammetry. The result of the modelling of the built environment is therefore a digital model that is as congruent as possible and geometrically consistent with the work carried out. The model obtained is also enriched with

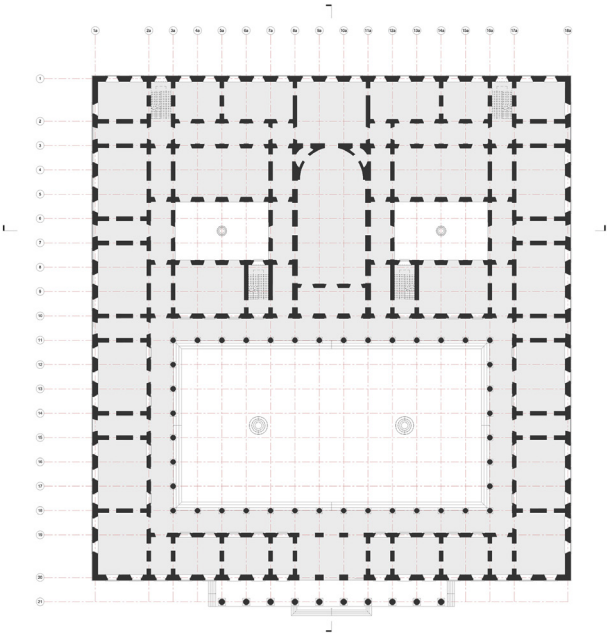
Tab. 1 Some of the characteristics of the three main categories of software involved in the process database [graphic elaboration Raffaele Argiolas, scientific coordinator Vincenzo Bagnolo].

	Vectorial drawing	3D modelling	BIM
Raster to vectorial	✓	✓	✓
Advanced custom graphic	✓	×	×
3D modelling	×	✓	✓
Parameterisation	×	✓	✓
Models for virtual environments	×	✓	✓
Data adding	×	×	✓
Automatic drafts generation	×	×	✓

semantic information deriving from in-depth documentary and archival analysis.
In the case of architecture on paper, a different approach is required. The digital reconfiguration in this case represents an interpretative tool that from the paper supports the reading and understanding of the project.
On the one hand, the overabundance and heterogeneity of information and details makes it difficult to be read, also because of the disunity of the various documents; on the other hand, it makes it possible to gain greater knowledge of the work and to better read, understand and translate its latent meanings. There are therefore substantial differences in approach compared to the modelling of the existing. These differences are due to the existence of a more complex process of critical interpretation resulting from an approach that admits and maintains the existence of different levels of uncertainty. This is a circular process that does not end with the initial process of reading the drawings but is also reiterated in the modelling phase whenever a new meaning is encountered, even if potential and not clearly represented or communicated. Based on what has been previously written, it has been decided to conduct the digital reconfiguration of the paper documents of the thesis project for a Court of Appeal through the identification and classification of three different levels of information: overt information, inferred information and latent information.
Obvious information is that which is clearly and directly evident from the drawings.
Deduced information, on the other hand, is not explicitly stated, \but can be interpreted and deduced through reasoning on the drawings of the project itself. An example is the interpretation of the design of the side and rear elevations. The case study has in fact some information gaps regard-

ing the three elevations, which do not appear in any of the drawings. However, it was possible to hypothesise the design during the modelling phase, based on the scanning of the elements that make up the main elevation. Through the comparative reading of the main elevation and the recognition of common elements in the plan, it was possible to hypothesise the vertical scanning of the smooth basement - facade treatment with continuous horizontal strips and crowning with projecting moulded cornice. It was also possible to hypothesise with a good level of certainty the scansion of portals and windows, associating each time style, geometry and position of mouldings and string-course cornices, based on compositional logic already explained by the author. The axonometric view in figure 6 shows the result of this interpretation.
Through the redesign of the plan, it was also possible to trace the primary compositional matrix. The planimetric composition is in fact based on a regular grid with a square module of four meters on each side (Fig. 6).
The latent information is also information that is not clearly explained in the drawings but, unlike the deduced information, it can be deduced indirectly through the study of the historical and cultural context in which the work is inserted, the comparison with historical treatises, with other works by the author or with works that are similar in terms of time, culture and territory to the case study.
An example is given by the interpretation of the design of the capitals of the columns that mark the galleries of the central vaulted hall, visible in the axonometric cross-section in figure 8. The level of detail of the author's original longitudinal section did not allow the exact design of the capitals to be read.
It was certainly possible to identify a Corinthian-style capital, but it was not possible to have a more detailed geometric description of its components.
In the modelling phase it was therefore chosen to refer to the parametric modelling of the typical Corinthian capital exposed by Aubin [Aubin 2014].





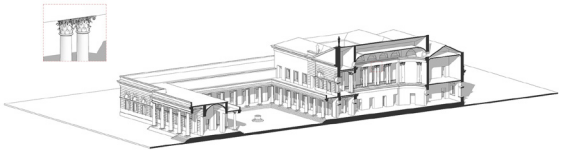


Fig. 6. Axonometric view database [graphic elaboration Simone Cera, scientific coordinator Vincenzo Bagnolo].

Fig. 7. Digital reconfiguration of the general plan of the Palace of Justice with the modular grid [graphic elaboration Simone Cera, scientific coordinator Vincenzo Bagnolo].

Fig. 8. Longitudinal axonometric section. A detail of the model of the Corinthian capitals of the second order of the main hall [graphic elaboration Simone Cera, scientific coordinator Vincenzo Bagnolo].

Another example is that of the Tuscan-style columns framing the central courtyard, which are also repeated in giant order on the main façade. In the interpretation of these elements, it was decided not to model the entasis of the shaft. Even though the Tuscanic order provides for this optical device of the shaft, it was decided to carry out the modelling in coherence with the original design of the author who, for reasons probably linked to time and the level of detail of the work, decided to neglect its representation. One of the interesting future developments is certainly that of assessing the typological and stylistic consistency of the elements through comparison with the most important reference treatises.
Through the study of the project, a methodological approach like that formulated for the survey of the existing, which we know is a process of awareness of the work. The process is therefore the result of choices and interpretations guided by a critical judgment capable of offering one or more keys to interpreting the case study.
The approach to the digital reconfiguration of the case study was conducted through the *Autodesk Revit* software, with which it was possible to create a model from which to extract various types of drawings that allow to extrapolate and relate a series of information in graphic or tabular format.
It was also decided to create special instance attributes, applicable to objects and rooms, which would allow the 4 degrees of deduction used in the parts modelling phase to be kept track of. Grade 0 is assigned to objects and environments for which no interpretative effort was required, as they are clearly and completely evident from the drawings. Grade 1 indicates that the object or environment is present and certain in the drawings, but not evident in its representation. Two examples of the assignment of this parameter are the functional program and the diagram of the hierarchy of serving and served environments. Grade 2 is assigned to objects and environments represented in the drawings but lacking in information for various reasons such as the scale of representation. Grade 3 is assigned to objects and environments not represented in the drawings and modelled based on deductions from information extracted from the project drawings and external sources. Any other graphic elaboration and analysis will be based on the model and the drawings produced through *Revit* but will be developed through the search for interoperability with other more suitable tools.
The analysis will then focus on further available documents

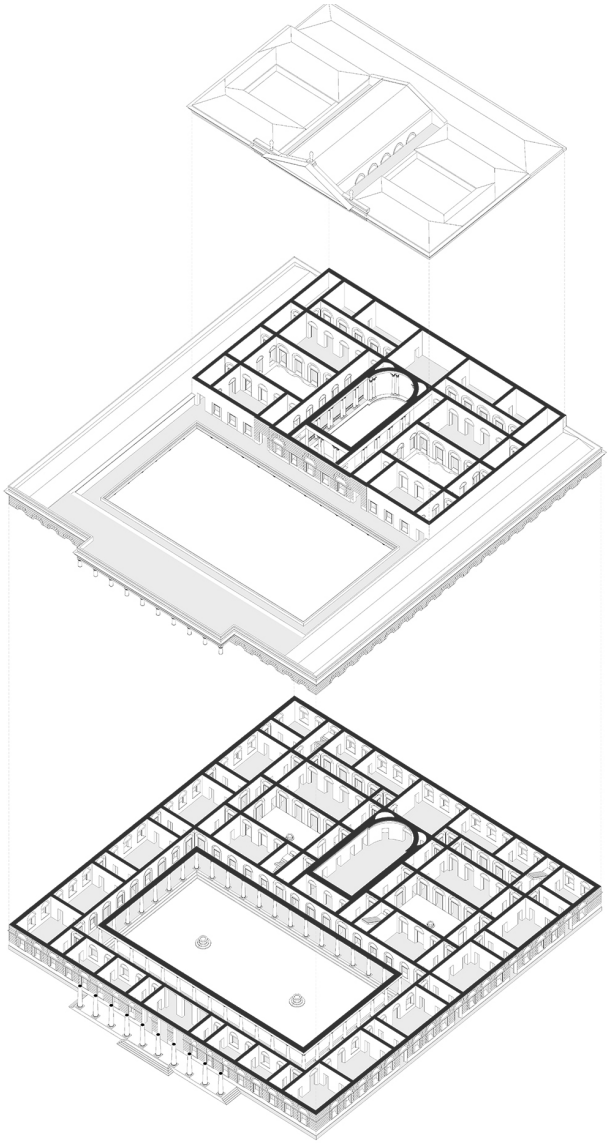
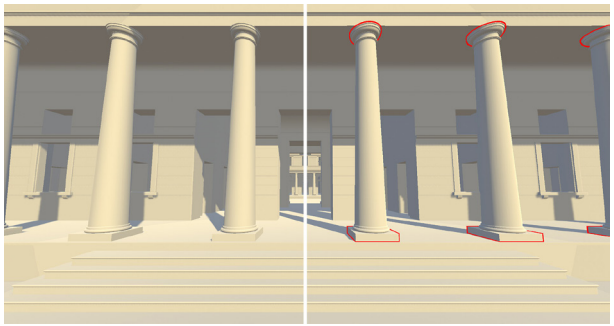


Fig. 9. Axonometric exploded view [graphic elaboration Simone Cera, scientific coordinator Vincenzo Bagnolo].

from the archive. In this way, it will be possible to extrapolate and relate - through the definition of appropriate parameters and the use of appropriate tools - a series of information from different case studies and produce works related to the work but not present among the original ones (Fig. 9) that are able to open up new interpretations of the meanings of the works.

Virtual tour

One of the uses of BIM models for communicative and didactic purposes that is finding more and more space in research is the development of virtual environments, understood as simulated spaces that can be crossed and interacted with by the user. In the cultural heritage sector, where technologies such as virtual reality, augmented reality and other forms of mixed reality have been experimented for some time [O'dwyer et al. 2021], the tool of virtual tours is widely used for the promotion and communication of cultural heritage [Arcese, Di Pietro, Guglielmetti 2011, Bekele et al. 2018]. This has led to increasing integrations between game engines and BIM models in order to exploit the hierarchies and information that the latter match the modelled objects [Bagnolo et al. 2021b; Milkova, Chadimova, Manenova 2019].
For the transposition of the Court of Appeal model into a virtual tour, it was decided to adopt the *Unity* game engine as the development environment; the choice is dictated by the relative simplicity in the initial stages of small prototype development and the wide range of free assets available; other game engines, such as the Unreal Engine, might be superior in aspects such as rendering power and photorealism [Christopoulou, Xinogalos 2017], but these are aspects that are beyond the scope and level of development established for the tour in question.
The transfer of models from *Revit* to *Unity* was done through the FBX format, which is handled natively by both software; moreover, this format allows preserving settings such as materials, element hierarchies, as set in *Revit* [Lee et al. 2019].
By means of a basic movement system and the preconfigured collision system in *Unity*, the model becomes an explorable environment for the user (figs. 10, 11); in addition to movements the user has available actions such as climbing or descending stairs, jumping, or 'falling' from elevated parts, making the model fully explorable.



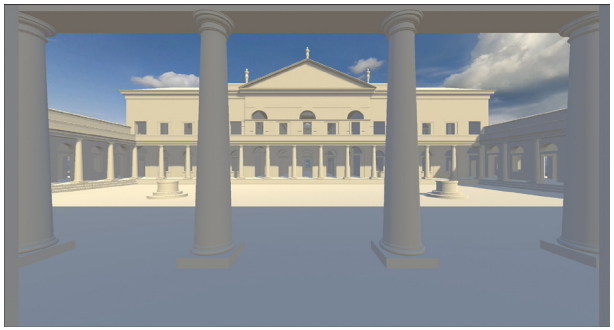


Fig. 10. The entrance to the complex in the virtual tour. On the right, an example of identifying elements with a certain degree of uncertainty in modeling [graphic elaboration Raffaele Argiolas, Simone Cera, scientific coordinator Vincenzo Bagnolo].

Fig. 11. View of the main courtyard in the virtual tour [graphic elaboration Raffaele Argiolas, Simone Cera, scientific coordinator Vincenzo Bagnolo].

Finally, by clicking the mouse, the user can interact with some of the objects on the tour by activating a colored border that identifies the degree of deduction described in the previous chapters.

Conclusions

With the advent of technologies for the communication of cultural heritage, traditional archiving and representation tools are no longer able to meet the needs of a large and 'new' audience. Creating content that establishes personalized and participatory user experiences must be one of the goals of digitization. It is necessary to respond to the growing need for additional functions to those that typically characterize the protection and enhancement of archival assets. This need is particularly evident and felt when we refer to architecture archives. The attention of the scientific community to the Archives of Architecture is now consolidated by initiatives and research that animate the debate on the so-called "paper architectures", as in the emblematic case of the project "Drawing in the Archives of Architecture" of the Unione Italiana Disegno [1].
One of the objectives of our research is undoubtedly to activate a path of knowledge of the heritage held by the DICAAR, documents that must also be included within the framework of the academic training courses of the Regia Università di Cagliari.
A first approach to the study of this heritage, preparatory to the census and the archival descriptions of the documentary units, necessarily passes through a reorganization of knowledge. A preliminary analysis of the information to guarantee an effective narration in a digital environment is also necessary. This introductory phase is essential to define effective tools functional to scientific research. At the same time, the new tools are also aimed at general users by supporting the enhancement of documents in the different forms allowed by technologies for the communication of cultural heritage. The methodology is based on the correlations between the operational aspects connected to the data and the construction of new meanings. The creation of thematic catalogs is further enriched through the implementation of technologies such as augmented reality, virtual tours in immersive environments, animations or training experiences through the creation of serious games.
Enhancing the latent contents of paper drawings and involving users in an active participation system also means defining a new digital space. In the case of architecture archives, this means taking on a new role very close to that of the virtual museum, where remote visitors feel free to access the narrative in a casual way or at least in a non-linear way [Rota 2015] in the now changed role of the visitor who becomes a "visit-actor" [Sangiorgi 2015].
The neoclassical culture of architectural design defines a theoretical operation of conformation of spaces and, at the same time, represents architecture in all its parts with a rigorous control of the individual elements. In the digital reconfigurations of the paper architecture, it was decided to operate in a BIM environment. This choice derives in part from some typical characteristics of neoclassical architecture but, mainly, from some advantages that this methodology offers within the proposed workflow. In addition to providing the tools typical of all standard 3D modeling environments, BIM allows you to impose relationship constraints between elements, offering the advantage of identifying recurring construction elements in different projects. This allowed us to model the individual elements in shared families and catalog them in analytical schedules. In the case of architectures that have never been built, the BIM environment facilitates the validation of the constructive consistency of the project. In addition, by creating instance attributes, the BIM environment offers the possibility of graphically translating the different degrees of uncertainty of the digital model. These levels of uncertainty typically derive from deficiencies in the starting information of the drawings. These may be due, for example, to the adoption of a certain reduction scale or to the lack of representation of some parts of the building, as happens when there is a drawing of only one elevation. In the digital model, these 'gaps' are filled by deducing the missing information from the other graphics.
The workflow is not meant to be the final output of the research. The workflow composes the steps of an integrated knowledge process between archive and design aimed at defining some models and digital tools for the enhancement and communication of paper architectures. In a multidisciplinary approach, in addition to the necessary involvement of archival sciences, a further extension of the tools may derive from the contributions of disciplines such as the history of architecture, architectural and urban composition or museology. In the long term, this multidisciplinary approach aims to define a methodological proposal that is no longer just occasional but generates a scientific criterion that can also be applied to other contexts.

Credits

Luigi Arthemalle Persi's drawings are in possession of the DICAAR - University of Cagliari. This article is the result of the joint work of the authors; in particular Vincenzo Bagnolo is mainly responsible for the paragraphs "Introduction", "The pupils of Gaetano Cima" and "Conclusions"; Raffaele Argiolas is mainly responsible for the paragraphs "Database", "BIM modeling for designed architectures" and "Virtual tour"; Simone Cera is mainly responsible for the paragraph "The BIM model". "Il modello BIM".

Note

[1] <https://www.unioneitalianadisegno.it/wp/archivi/> (accessed 20 April 2022).

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